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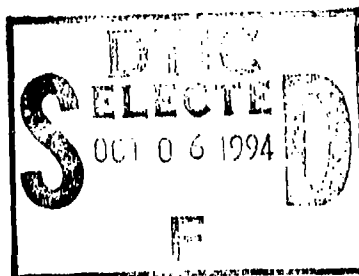F

AN ANALYSIS OF THE EFFECTS OF LEAN
LOGISTICS ON THE CURRENT AIR FORCE
REPARABLE PIPELINE: A SIMULATION
STUDY

THESIS

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AFIT/GLM/LAL/94S-22

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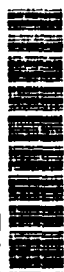and do not reflect the official policy or position of the
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AN ANALYSIS OF THE EFFECTS OF LEAN LOGISTICS ON THE CURRENT

AIR FORCE REPARABLE PIPELINE: A SIMULATION STUDY

THESIS

Presented to the Faculty of the Graduate

School of Logistics and Acquisition Management of

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for the Degree of Master of Science in

Logistics Management

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Table of Contents

List of Figures

List of Tables

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Abstract

This research investigates the effect of Lean Logistics proposals on the current Air Force reparables pipeline. First, Lean Logistics proposes reducing reparable asset levels stocked at operating bases and relocating many of these assets at an intermediate supply point located at the depot. Secondly, Lean Logistics proposes large reductions in asset transportation time between the bases and the depot. Finally, Lean Logistics proposes streamlining the depot repair process such that depot repair times are significantly reduced.

Computer simulation is used as a tool to perform a 3X3 full factorial experiment to determine the effect of asset levels, depot repair time, and transportation time on aircraft availability and transportation costs. Results indicate that neither the Lean Logistics nor current pipeline configuration is the optimal performer. However, results do indicate that Lean Logistics outperforms the current reparables pipeline in terms of aircraft availability and in terms of total cost of assets in the system vs. cost of transporting those assets through the system.

AN ANALYSIS OF THE EFFECTS OF LEAN LOGISTICS ON THE CURRENT AIR FORCE REPARABLE PIPELINE: A SIMULATION STUDY

I. INTRODUCTION

General Issue

Lean Logistics (LL) is a relatively new logistics concept developed to streamline reparable asset repair, asset stockage, and transportation segments of inventory management. Personnel at the Air Force Materiel Command (AFMC) have proposed this system as a response to budget cuts and force reductions in order to become more cost efficient and more mission effective. LL proposes consolidation of a large portion of the assets currently stocked at base level to an intermediate supply point that will manage such reparable assets for several bases. LL also proposes to greatly reduce transportation times, decreasing the overall length of the pipeline. Additionally, LL proposes to streamline the depot repair and remanufacturing function. Personnel at AFMC anticipate that the combined effects of these actions will lower overall inventory costs (HQ AFMC Slide Package, 1993). This research analysed the effects of applying ⅃ concepts on fully mission capable aircraft and the costs associated with transporting and storing needed assets.

Background

There are many reasons that Air Force personnel are making such concerted efforts toward streamlining existing systems. The Soviet threat has had a major impact on United States (US) defense decision making for over four decades. The US continually prepared for both a nuclear attack and a short warning invasion of Western Europe that would leave little time for preparation. During this period, the defense strategy required large US combat forces to operate in forward locations at high states of combat readiness to confront a numerically superior enemy. With the collapse and disintegration of the Soviet Union and Warsaw Pact, the US is the only remaining super power. Even considering that the future political situation remains uncertain for the former Soviet Union and its allies, there are, in all likelihood, no new threats that can measure up to the old menace.

There are, however, plenty of other potential challenges to face. In the absence of Soviet control, there have been serious disagreements concerning the boundaries of the former Soviet republics and a resurgence of national and ethnic conflicts. The Middle East continues to be an area of turmoil. In Asia, tension exists between India, Pakistan and China. In Latin America, numerous conflicts threaten stability. Open conflict continues in Africa (Rich, 1991). To handle these challenges, the overall strategy has shifted

toward smaller US force levels both at home and overseas with lower operating tempos. The US is structuring its forces to have the ability to win two simultaneous regional conflicts (Nunn, 1992).

Coincident with the end of the cold war, this nation faces unprecedented national debt and massive annual deficits that demand a comprehensive solution. Taking advantage of the opportunities afforded by the diminished superpower rivalry, part of this comprehensive solution has been to pursue reductions in the defense budget. To this end, the Secretary of Defense has initiated a bottom-up defense review to transition the military services to a leaner force structure for post cold war challenges (HQ AFMC Slide Package, 1993).

The Department of Defense (DoD) is currently undergoing an extensive drawdown of military forces. The drawdown includes closing hundreds of installations, deactivating a third of the Army's divisions, mothballing 20 percent of the Navy's ships, removing 70 percent of the country's strategic nuclear warheads from deployed status, and deactivating one quarter of the Air Force's tactical fighter wings (Nunn, 1992).

Facing these increasingly stringent fiscal constraints, the Air Force is developing more efficient methods of managing reparable assets. Recently, DoD and Air Force agencies seem to be adopting more of a "business-like"

3

mentality in resource management. Just-In-Time (JIT) methods of inventory management are one popular way that private industry has been managing its resources (Gray and Smeltzer, 1989:746). These methods have shown themselves to be extremely efficient for many businesses over the last few decades (Osborne and Gaebler, 1993:xv-xxii).

The LL concept is still somewhat nebulous. It focuses on consolidating existing inventories, reducing reparable asset transportation times, and streamlining reparable depot repair actions. Yet, the Air Force employs a wide variety of weapon systems for many specific purposes in a diverse set of locations. LL personnel anticipate that changing the way in which the reparable asset pipeline and repair process are managed will greatly reduce asset requirements, maintain an established level of weapon system performance, and will equate to significant reparable cost avoidance. As such, the LL concept is a policy, or combination of theories that will be applied to each weapon system according to the unique requirements of that weapon system. This research uses the B-1 weapon system and a simulation to examine the effects of Lean Logistics on fully mission capable aircraft, as well as costs associated with transporting these required assets (HQ AFMC Talking Paper, 1993).

Specific Problem

Lean Logistics is a philosophy of operation that seeks to improve the responsiveness of the Air Force logistics pipeline by consolidating the reparable asset pipeline and streamlining the flow of assets through the repair process. However, in order for the change to the new policy to be positive, it is important that consolidating the pipeline and changing depot repair processes do not degrade current weapon system performance.

First, LL proposes to introduce a Intermediate Supply Point (ISP) to the existing system and relocate the majority of base assets at this facility. Relocating assets will theoretically provide asset managers with greater flexibility in distributing assets and possibly reduce the overall number of assets required in the system to maintain the same number of fully mission capable aircraft.

The second major proposition of LL is to reduce the transportation time standards for reparable shipment to base from the depot and retrograde shipment from the base to the depot. This reduction in transportation time is the main thrust that reduces asset requirements in the overall system. The reduced transportation time compresses the pipeline, and thus minimizes asset needs during resupply.

The third major thrust of LL is to streamline the current depot repair cycle process. The current method of depot reparable asset repair requires that item managers meet on a

5

quarterly basis to decide which assets will be inducted into repair that quarter. LL proposes to use the Distribution and Repair in Variable Environments (DRIVE) system on a bi-weekly basis to compute a prioritized list of the assets requiring repair that will most improve overall fleet fully mission capable aircraft. The list generated by DRIVE is then used to decide which assets are selected for induction into repair (Abell, 1992:10-12). Therefore, the new system proposes review of asset requirements on a much more frequent basis to maintain a more responsive system. In addition, the Theory of Constraints will be applied to the actual repair processes in order to gain insight about potential consequences of specific changes in the logistics system (HQ AFMC Slide Package, 1994).

This research analysed the effects of applying LL concepts on the number of servicable assets in assigned aircraft and warehouses, as well as the costs associated with transporting needed assets. The system introduces three fundamental changes to current pipeline operations. However, those three changes imply a shift of paradigm in pipeline management. Identification of the level of improvement that Lean Logistics will administer in system performance will help LL personnel to better perform cost benefit analyses on whether the investments to implement LL are worth the benefits derived in the long run.

Investigative Questions

The following are questions about Lean Logistics that this research will answer:

1. *What are the specific effects on estimated th number of fully mission capable aircraft, within the context of the various experimental treatments, of varying asset stock level, transportation time, and depot repair time?*

2. *What are the specific effects on the cost of transporting the assets in the system, within the context of the various experimental treatments, of reducing asset stock level, transportation time, and depot repair time?*

Limitations of the Study

This research was designed to analyze the effects of consolidating assets at an intermediate supply point and reducing transportation time and depot repair time as proposed under the LL concept. Listed below are the limitations that defined the scope of this research.

1. A peacetime environment was assumed. Desert Storm showed that logistics pipeline operations are modified considerably during wartime (Adams and others, 1993:20-21). The assumption of a peacetime environment allowed the research to obtain stability and consistency in findings in order to draw valid conclusions. Peacetime operations had the greatest probability of providing consistent actions and results.

2. Only continental United States (CONUS) movement of

reparable assets for the B-1 weapon system were considered.
This weapon system was chosen because of its use at a
limited number of Air Force locations. Study of such a
limited weapon system allowed for more comprehensive data
collection on the movement and repair of assets for the
weapon system as a whole. However, this limits the study in
the respect that conclusions or findings only pertain to the
weapon system studied and not to all Air Force weapon
systems.

3. The repair and remanufacture activity within the depot
was simplified to the use of repair capability rates,
condemnation rates, and repair times. Closer examination of
the depot maintenance function would have vastly changed the
scope of the problem. Therefore, the depot repair process
and reparable repair times required were assumed as given
and correct. The various shop flows were translated into
different repair times which are more easily handled for
this research. Thus, this assumption limits the findings of
the study in that specific depot repair activities may, in
fact, significantly affect pipeline activities. Thus, this
assumption limits the findings of the study in that specific
depot repair activities may, in fact, significantly affect
pipeline activities.

4. Only the top five demand reparable components of the B-1
were used in the simulation. The study of five line items
provided adequate data to make an assessment of the activity

of the top demand reparables for the B-1 aircraft. These
five assets were chosen through the use of Dyna-METRIC
assessment model. Dyna-METRIC is a model used to
analytically forecast how component support processes will
affect military weapon system's wartime capability (Pohlen,
1994).

5. The various rates, durations, probabilities, and levels
used as parameters in the research were gathered from models
and databases used in current Air Force reparable pipeline
operations.

Specifically, transportation times were drawn from the
Uniform Materiel Movement and Issue Priority System (UMMIPS)
Standards. Traditional depot repair times were gathered from
the Recoverable Consumption Item Requirements System (D-041)
and manipulated according to assertions in the LL proposal
to derive the LL levels. Initial asset levels at the
various warehouses were calculated from existing pipeline
formulas used in USAF reparable item management. Elements
needed for these formulas were drawn from the D-041
database. All values were assumed to be accurate depictions
of pipline operations.

The research alters three independent variables at three
levels to determine results of two dependent variables.
Simulation was used to model the pipeline with its given
limitations. An analysis of variance test was then
performed to show the differences between treatments with

9

respect to the dependent variables.

Organization of the Research

Chapter two of this thesis will review available literature on Lean Logistics, data collection strategies applicable to the research, and current requirements computations strategies and tools applicable to today's Air Force reparable item management. Chapter three will describe how simulation and non-parametric analysis of variance tools were used in deriving data and statistical findings. Chapter four enumerates the findings of compiled data, and chapter five lists conclusions, recommendations, and reasons such conclusions were drawn.

II. LITERATURE REVIEW

Introduction.

This chapter provides a review of the literature pertaining to Lean Logistics and subjects needed to perform this study. Specifically, the chapter begins with a brief background on the traditional logistics pipeline and its components. It then proceeds with an introduction to Lean Logistics and its evolution, followed by its underlying theories. The LL philosophy is described in some detail, followed by data collection strategies used in the research. Finally, the chapter concludes with descriptions of current USAF requirements computation tools and theories.

Logistics and the Traditional Reparable Pipeline.

Logistics. The reparable pipeline is best understood when viewed as a major logistics process flow. Before fully understanding the pipeline, one must be able to understand the term logistics. The following definitions provide different viewpoints of the term and its application in the field.

The seven Rs definition of logistics is often cited as getting "the right product, in the right quantity and in the right condition, at the right place, at the right time, for the right customer, at the right cost." (Coyle and others, 1992:6). The Council of Logistics Management definition,

11

cited by Blanchard in *Logistics Engineering and Management*,
is as follows:

> Logistics is the process of planning, implementing, and
> controlling the efficient, effective flow and storage
> of raw materials, in-process inventory, finished goods,
> services and related information from point of origin
> to point of consumption (including inbound, outbound,
> internal, and external movements) for the purposes of
> conforming to customer requirements. (Blanchard, 1992:
> 3)

The Society of Logistics Engineers, cited by Coyle in *The
Management of Business Logistics*, defines logistics in this
way:

> The area of support management used throughout the life
> of the product or system to efficiently utilize
> resources assuring the adequate consideration of
> logistics elements during all phases of the life cycle
> so that timely influence on the system assures an
> effective approach to resource expenditures. (Coyle and
> others, 1992:8)

Pipeline. Given all its various inputs and internal
functions, the Air Force logistics system's end product is
war fighting capability. It is often referred to in common
language as the "Pipeline." The analogy of a pipeline is
useful to visualize the flow of assets through the logistics
system in much the same way that liquid flows through a
physical pipeline. A physical pipeline has properties such
as routing, volume, and length. The routing shows the
movement of assets through the various functions and
processes of the logistics system. The volume indicates the
quantities of assets in the system, and the length of the

12

pipeline denotes the times involved with moving assets from one point in the system to another(Bond and Ruth, 1989:5). Figure 1. depicts the overall logistics pipeline and how the various segments relate to one another. The Air Force logistics pipeline consists of the acquisition, depot, base, and disposal subsystems. These subsystems contain the following components: supply, maintenance and distribution (Bond and Ruth, 1989:3). The subsystems and components, taken together with the intervening transportation legs, comprise a basic view of the Air Force logistics pipeline.
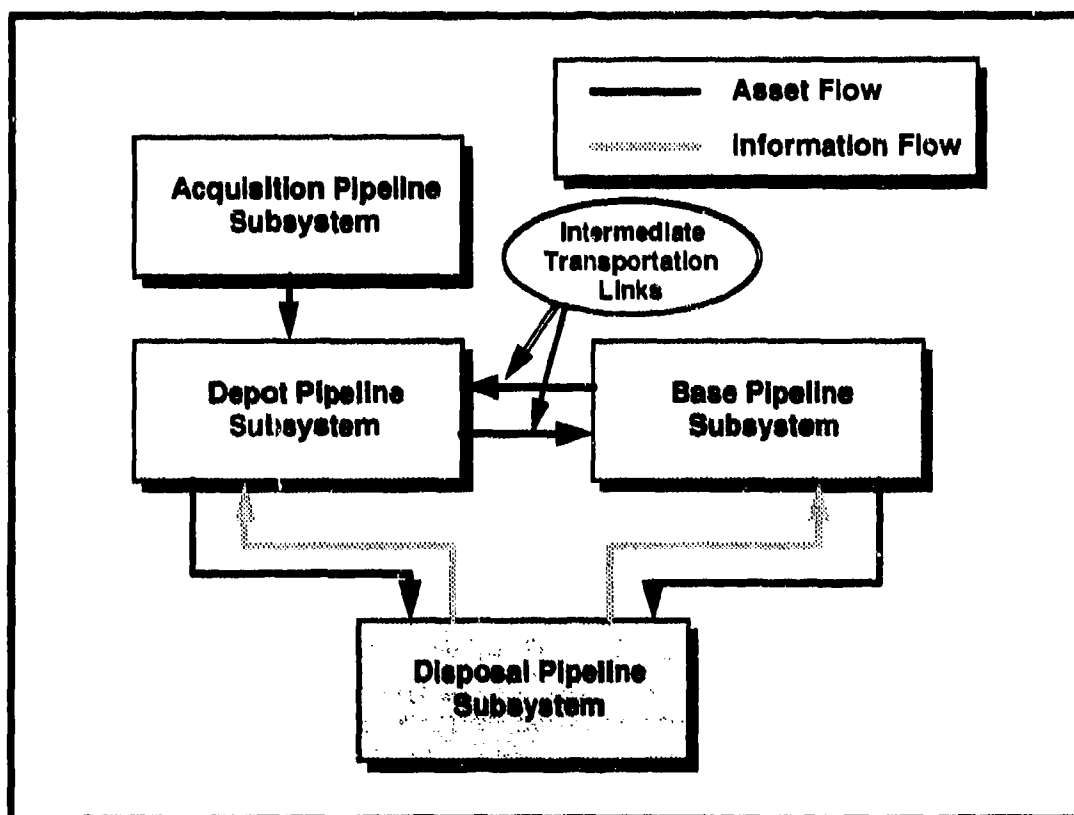
Figure 1.   The Overall Logistics Pipeline (Bond and Ruth, 1989).

13

Acquisition Pipeline Segment.   The acquisition
pipeline is divided into three primary activities: (1) the
development of an acquisition plan, (2) the contracting
process, and (3) industrial capacity and its effects on
procurement lead time. When creating an acquisition plan,
experts must use a requirements determination system to
establish a statement of need. Reparable assets comprise
less than twenty percent of the USAF inventory, but they by
far exceed all other assets in dollar investment.
Therefore, it is important that the statement of need is
accurate so as not to overspend government dollars or
understate requirements. Statements of need are established
on the basis of historical demand, taking into consideration
life cycle costs and other pertinent factors about the
asset. After establishments are determined, a required
delivery date is established and the contracting process
begins. The development of an acquisition plan contributes
to administrative lead time(Bond and Ruth, 1989:137).

14
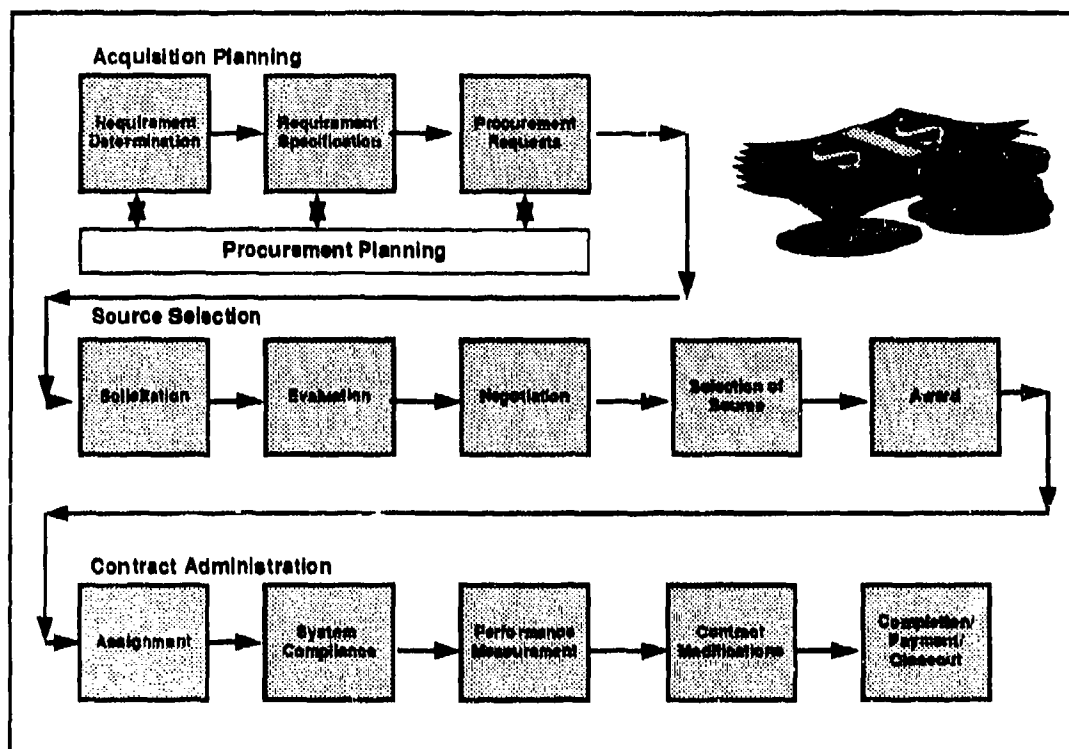
Figure 2. The Federal Contracting Process (Templin, 1993).

The contracting process consists of acquisition
planning, source selection, and contract administration
phases (See Figure 2)(Templin, 1993). Acquisition planning
was described above. The source selection process tries to
efficiently select and award contracts, thereby minimizing
total procurement costs. The contract administration
process follows procedures designed to force contractor
compliance in order to keep asset deliveries on schedule and
maintain established contract prices. The contracting
process also contributes significantly to administrative
lead time. Industrial capacity refers to the US industrial

15

base's ability to manufacture and distribute military spares. This aspect of the acquisition pipeline often serves as a constraint to asset receipt. A lack of selection in available contractors or limited production capacity from existing contractors often deters completion of established contracts, thus increasing production lead time(Bond and Ruth, 1989:140).

The acquisition pipeline is very important to overall Air Force pipeline operations, and is often ignored in pipeline analysis(Bond and Ruth, 1989:140). This is the starting point from which all other pipeline segments stem. If its activities are not performed as planned, there is little that the base and depot can do to overcome difficulties.

Depot Pipeline Segment. The depot segment of the AF reparables pipeline is comprised of five Air Logistic Centers (ALCs), each one providing similar maintenance and supply functions. The maintenance activities can be summarized into two categories: overhaul of weapon systems and repair or remanufacture of reparable assets. The depot level constitutes the highest level of maintenance, and supports the accomplishment of tasks above and beyond the capabilities available at the base level. Typically, the depot is a specialized, fixed repair facility supporting a number of systems and equipment. Complex equipment and environmental controls are often present(Blanchard,

1992:116). The storage and issue supply functions stock supplies in two ways: those used by the ALC and those used by the bases supported by that ALC.

"Depot maintenance accounts for a large share of total assets held in the pipeline and for a significant portion of the pipeline time used while assets are repaired and returned to field usage." (Bond and Ruth, 1989:96). The flow of reparable assets within the depot subsystem is similar to the flow within the base subsystem. Parts arrive from bases and other depots for repair and are held until the production shops are ready for them. Batch processing has been the traditional form of process technology utilized in the repair and remanufacture of reparables. Batch production processes are used to produce small lot sizes of similar products. Products are processed in batches with short production runs using essentially the same sequence of operations(Evans, 1993:128). However, for different types of reparables, the shop flow can be quite diverse, using different sequences, machines, and resulting in a vast range of repair times. Once the production shops have performed corrective actions, the parts are routed back to depot supply and are available to fill demands from the various bases(Bond and Ruth, 1989:98). Figure 3. provides a basic view of the Depot Repair Pipeline.
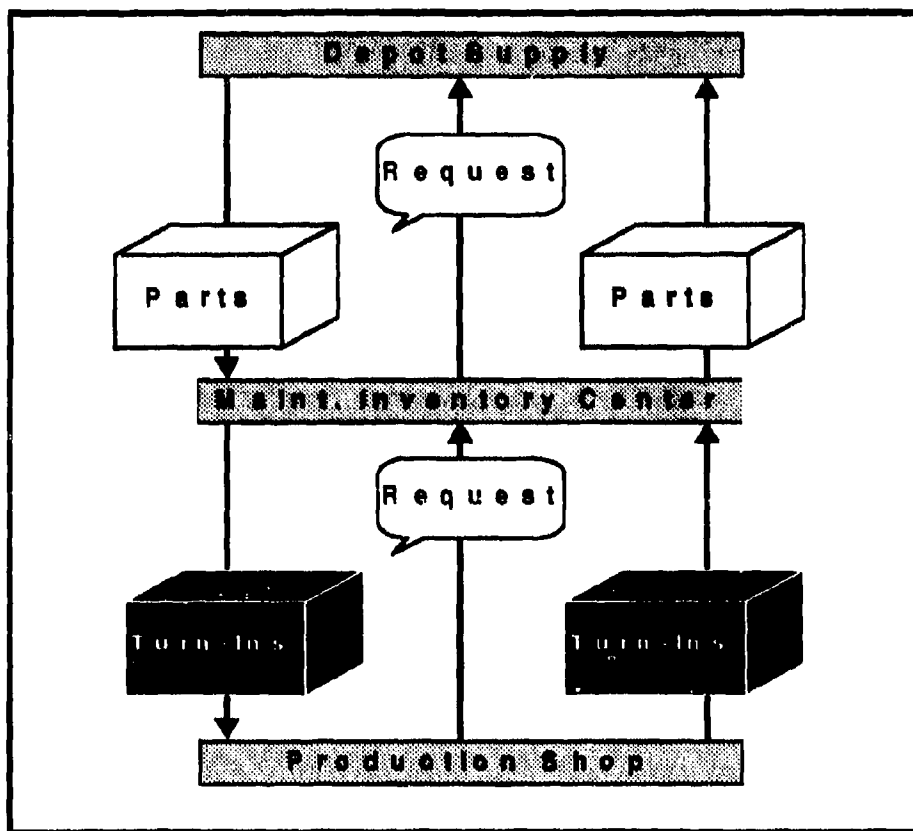
Figure 3. Basic Depot Repair Pipeline (Bond and Ruth, 1989:99).

Base Pipeline Segment. Organizations at the base level are generally considered to be the customers or users of the pipeline because of their direct and immediate impact on mission accomplishment and combat readiness. Base requirements and demands determine what is currently in the pipeline and what will be in the pipeline in the future. The base segment of the reparables pipeline is composed primarily of maintenance and supply activities.

These activities can be summarized by what is known as the base repair cycle. During preventive or corrective maintenance, a maintenance technician identifies an unserviceable part and places a demand for that part on the base supply function. If the part is on hand, base supply issues that part for the repair of the aircraft, engine, or similar end item. The faulty part is evaluated by the base maintenance function to determine if it can be repaired at the base. If the part is repaired at the base, it is then returned to base supply to satisfy future demand. If the part is not repaired, it is either condemned and returned to base supply or returned to base supply as Not Repairable This Station (NRTS). Condemned assets are sent to the Defense Reutilization and Marketing Service (DRMS) for salvage. NRTS assets are sent to the appropriate depot for higher levels of repair or remanufacture. When an asset is condemned or turned in NRTS, a demand is placed on the depot for that part to replenish base supply stockage levels(Bond and Ruth, 1989:25-29).

Disposal Pipeline Segment. This portion of the logistics pipeline is introduced when an asset reaches its "twilight period." If neither the base nor the depot have repair capability for a failed asset, then it is classified as salvage. Assets that have been condemned, can no longer be repaired or reused, are sent to the Defense Reutilization and Marketing Service. Once an asset becomes DRMS

property, it remains at that location until another user is found, it is donated to a qualified organization, or is sold to the general public. Assets that cannot be redistributed to the public are usually demilitarized before shipment (Bond and Ruth, 89:142-143).

Transportation Pipeline Segment. The intervening transportation segments between the primary subsystems in the pipeline are often considered in terms of time. This is because the longer it takes to transport an item to its final destination, the more safety stock is necessary to be kept on hand to prevent stock outs and the subsequent reduction in mission capability. The largest factors affecting transportation times are the modes of transportation and the priority given to the item. According to Air Force Regulation 75-1, <u>Transportation of Material</u>, the mode of transportation is selected to get the asset of interest to its destination within the Uniform Materiel Movement and Issue Priority System (UMMIPS) time standards at the lowest cost. The UMMIPS establishes a priority system between depots and base-level supply organizations. According to Air Force Manual 67-1, <u>Basic AF Supply Procedures</u>, UMMIPS uses priority designators to demonstrate the importance of requisitions. A cumulative delivery time is established for each priority designator (AFM 67-1, 1986). Table 1. shows UMMIPS Time Standards in Calendar Days for current transportation standards. The far

right hand column shows the standard for the amount of time
each activity in the order and ship time should take. The
D-041 database uses this total order and ship time of 22
days as its standard for reparable asset stockage policy
computations.

Table 1. UMMIPS Time Standards in Calendar Days

Priority Designator Edit Req.	PD 01-08	PD 01-08 PD 01-15 for 444	PD 01-15
Pipeline Time Segment	RDD of 999, N___, E	RDD of 444. 555, 777	Blank RDD
Requisition Submission	1	1	2
Passing Action	.5	1	1
ICP Availability Determination	1	1	1
Depot Storage Site and/or Base Processing and Packaging	1	1	5
Transportation Hold and CONUS Intransit	1	4	10
Receipt Take-up by Requisitioner	.5	1	3
Total Order and Ship Time	5	9	22

The various modes of transportation available to a
transportation officer can be divided into two categories:
surface and air. The surface modes are trucks, railroads,
bus, postal service, and parcel service. The primary
advantages for trucks and railroad, under the right
conditions, are high accessibility and low cost,
respectively. Air carriers have the primary advantage of
low transit time(Coyle, 1992:203).

21

Lean Logistics and its Evolution.

Each one of the segments of the logistics pipeline plays an important role in the responsiveness of the overall system. The fundamental structure of the current logistics pipeline is not affected by the changes proposed under Lean Logistics. However, various operations within the depot, base, and transportation pipeline segments are virtually re-engineered under LL to meet the fiscal challenges imposed in today's political and economic environment(AFMC Slide Package, 1993).

Governmental budget cuts have affected employees throughout the DoD. Headquarters AFMC determined that its overall repair requirements for 1993 were $1.66 billion, but the command was only funded for $1.4 billion. Further, 1993 procurement requirements were calculated at $1.85 billion, with funding levels at only $410 million. Action had to be taken to avoid degradation of logistics support due to lack of asset availability(AFMC Slide Package, 1994).

RAND corporation of California regularly performed studies for the Air Force and DoD to assist in improving logistics operations. In the latter part of 1992, the Air Force logistics directorate (AF/LG) asked RAND to examine modern business practices and determining how they could be applied in the Air Force to minimize resource investments required for the maintenance of today's reparable logistics pipeline. RAND proposed conceptual ideas on how the Air

22

Force could use the Theory of Constraints and Just-In-Time practices to improve reparable depot repair processes and pipeline activities(RAND, 1992).

In February of 1993, RAND briefed the results of their study to a working group consisting of senior level members of the Air Staff and various major commands. It was at this point that the term "Lean Logistics" was coined, and the experts began defining specifically what it would do. From that point, RAND continued performing studies on the various portions of the depot repair process, and became more detailed in its analysis of how exactly the various concepts of LL would affect the pipeline(RAND, 1993).

Lean Logistics Philosophy. Lean Logistics has become one of the latest concepts for effecting large improvements in reparable item management within the Air Force. Although there are many proposed structural, organizational, and systemic changes in reparable management under LL, AFMC personnel assert that successful implementation of Lean Logistics will require a fundamental change in the way logistics personnel think. For example, the focus of management attention must shift from inputs to outcomes. That is to say, rather than ensuring a high utilization rate on a given machine or in a given shop, managers and workers will need to focus on repairing the right assets at the right time in the right quantities to satisfy demands. The

23

Air Staff describes LL as follows:

- Lean Logistics is a focused project to integrate state-of-the-art business practices across logistics
- It will improve and streamline policy, processes, and management structures which drive costs and investments in logistics infrastructure
- The end result is a smaller logistics infrastructure providing strong, less costly weapon system support to operational users, in peace and war. (HQ USAF Slide Package, 1994)

Information in Figure 4 is drawn from a briefing package prepared for General Yates in January of 1994. It outlines some of the "selling factors" of Lean Logistics(HQ USAF Slide Package, 1994). Table 2 compares some elements of traditional reparable pipeline management to the proposed LL methods of pipeline management.

- **Speeding up the repair, procurement, and transportation processes to provide parts on demand.**
- **Reducing base level spares/consolidating inventories.**
- **Involving the MAJCOM in repair and distribution of parts.**
- **An ongoing process of continuous improvement.**
- **Focusing on customer orientation /involvement and adopting Just-In-Time practices.**
- **Doing all these things to provide better support at lower costs.**

Figure 4. Factors Defining Lean Logistics

Table 2. Comparison Between Traditional and LL Pipeline Management.

Pipeline Factor	Traditional Pipeline Mgt	LL Pipeline Mgt
Transportation Time (serviceable and retrograde)	Follows UMMIPS standards (22 days)	Proposes 1 to 2 day CONUS shipment and 3 day overseas shipment
Depot Repair Process	Assets to be inducted into repair are reviewed quarterly and decided by item managers	DRIVE used bi-weekly to determine which assets will increase aircraft availability the most. Assets inducted according to this list.
Depot Repair Times	Averaged 54 days	Will average 10 days
Asset Consolidation	Majority of assets located at the bases; more assets needed to sustain the system	Assets withdrawn to an Intermediate Supply Point; less assets needed to sustain the system

The Air Force's transition into a Lean Logistics operation will require significant marketing efforts to all affected personnel. As with any major organizational change, a "buy-in" period must be established so that operators and managers of the system understand what they are doing and agree that it is in their best interest and for the betterment of the whole(HQ USAF Slide Package, 1994).

With respect to depot level maintenance practices, LL seeks to introduce Theory of Constraints and Just-In-Time concepts into the repair and remanufacture of reparable

assets to reconfigure the production process from a "push" system to a "pull" or demand based system. Under LL, the Major Commands (MAJCOM) will have greater authority to distribute remanufactured assets leaving the depots according to MAJCOM priorities. All of the distribution activities are performed to meet aircraft availability goals, lower inventory levels, reduce costs, and create simpler and more responsive operations(HQ AFMC Slide Package, 1993). Lean Logistics tackles virtually every aspect of the pipeline, with the exception of the acquisition process. At the time of this writing, LL did not involve any changes to the acquisition process. As such, the first segment of the pipeline that is examined closely is the depot segment.

 The Theory of Constraints. The primary change that LL institutes in the depot involves the repair process. LL attempts to override old asset repair practices with a relatively new production management theory called the Theory of Constraints. "The principle objective of constraint management, or Theory of Constraints, is to establish a process of continuous improvement through synchronized manufacturing." (Evans, 1993: 595). The operation with the least relative capacity is called the constrained resource. Constrained resources dictate the capacity and flexibility of the entire production operation. A constraint is any resource that prevents obtaining higher

levels of performance. For example, a constraint could be a limited capacity of a machine or work center, inflexible management or policies, or a labor shortage. Once the constraint has been identified, management focuses attention and resources on that constraint to link it directly to market demand and reduce its negative impact on the system. Once attention has been focused on the constraint, all other operations are scheduled on the basis of the constrained resource since it limits production to its capacity(Evans, 1993:595-596).

Just-In-Time Philosophy. In a Just-In-Time (JIT) system, an item is produced Just-In-Time for it to be used by the next process in the system. A primary goal under JIT is to reduce the costs associated with maintaining inventory to a minimum, or in other words reduce the costs associated with maintaining inventory to a minimum. JIT reduces inventory through the use of small lot, synchronized production of a leveled plan. JIT is often noted at a "pull" approach to inventory management. This "pull" approach is contrary to conventional "push" inventory systems.

> With the pull approach, a work center withdraws the required items for its production from the preceding work center. Then, the preceding work center would produce the exact quantity to replace parts withdrawn and would withdraw its required components from its own preceding work stations. This approach starts from the final assembly and goes back to all preceding work

centers including suppliers and vendors. (Gray and
Smeltzer, 1989:746)

In comparison to traditional inventory management, JIT
reduces inventories, employs shorter production runs,
minimizes waiting lines, uses short consistent lead times,
and relies on high quality components(Coyle and others,
1992:240). A JIT production schedule must be smooth and
repetitive. Otherwise, inventory levels would have to be
increased to compensate for the variations. This would be
contrary to the primary goal of JIT. (Gray and Smeltzer,
1989:747).

   LL and the Depot Activities. LL and depot activities
incorporate Theory of Constraint (TOC) philosophies to
minimize the amount of time spent fixing reparable assets.
Under traditional batch processing methods of reparable
assets at the depots, repair required an average of 54 days
to return an asset to an available status within the system.
Using TOC and focusing attention on streamlining depot
repair processes, Lean Logistics plans to reduce repair
times to 10 days(LL Slide Package, 1993). AFMC studies
indicate that the majority of "depot repair cycle time" is
actually time the asset spends waiting in repair and
transportation queues waiting to be inducted into repair.
LL proposes to focus repair attention and resources on those
assets that will improve aircraft availability for various
weapon systems. Therefore, although there will be more

setup and preparation involved for the repair of each asset
on a unit repair basis, critical assets will be repaired
more quickly. This will drive up the efficiency and
effectiveness of the depot repair process with respect to
aircraft availability(HQ AFMC Slide Package, 1994).

LL and the Depot to Base Interface. The primary
changes proposed under LL in the depot to base interface
segments involve the introduction of fast transportation and
an intermediate supply warehouse. Figure 5 shows the depot
to base interface, as well as the amount of time needed for
each function under the traditional and LL systems.
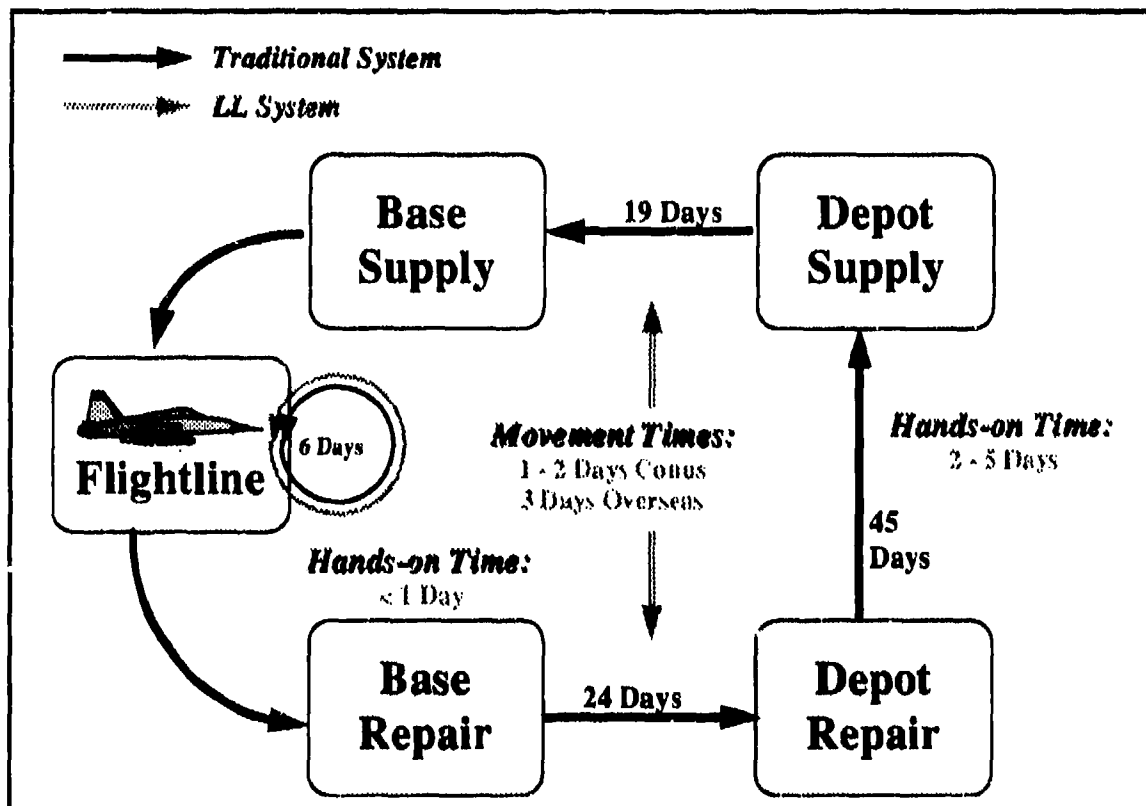
Figure 5. Interface of Depot and Base Activities With
Transportation Times.

Fast Transportation. Fast transportation simply means
that reparable assets ordered from depot will be shipped to
the requiring base within one to three days, depending on
the location of the base. Continental United States bases
should receive assets in one or two days, while overseas
shipments may require up to three days. Reduced in-transit
times will result in higher shipment costs but will offer
savings by decreasing the number of assets required in the
pipeline to maintain necessary asset availability. Figure
6 depicts the traditional transportation pipeline on the
left, given its various transportation modes. The right-
hand diagram shows the more immediate transportation methods
proposed by LL.

Intermediate Supply Points. There are several theories
behind establishing an intermediate supply warehouse (ISP).
The primary reason, however, is that it allows the Air Force
to minimize the number of reparable assets in the system by
reducing the number of stocked reparables at any given base
and positioning the ISP at a place where it can respond to
base demands more rapidly than before. In order to minimize
initial capital investments, headquarters AFMC personnel are
discussing the idea of co-locating ISPs with current depot
storage facilities. This approach shifts the focus on asset
management primarily to the transportation facet of the
proposal(HQ AFMC Slide Package, 1994). Reparable assets

constitute the majority of the Air Force asset investment by far, so it is imperative that these assets are managed properly.

Inventory Drives Infrastructure

Base Processes

Characteristics:
- Large Inventories
- Slow Transportation
- Batch Repair
- Long Queues
- High Cost

Long, Slow Pipelines

Base Processes Have:
- Big Operating Stocks
- Big Spares Kits

Depot Processes

Reduced Inventory/ Reduced Infrastructure

Base Processes

"Express" Pipelines

Characteristics:
- Small Inventories
- Optimum Repair Flow
- Rapid Delivery
- Continuous Improvement

Depot Processes

Figure 6. A Pictorial View of Traditional and LL Transportation Methods and Modes

31
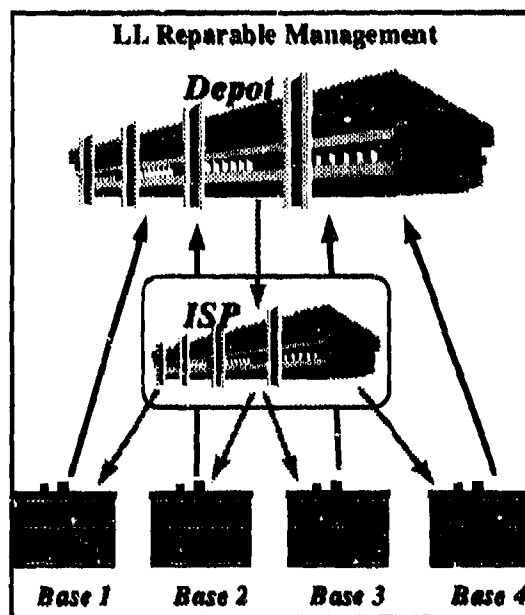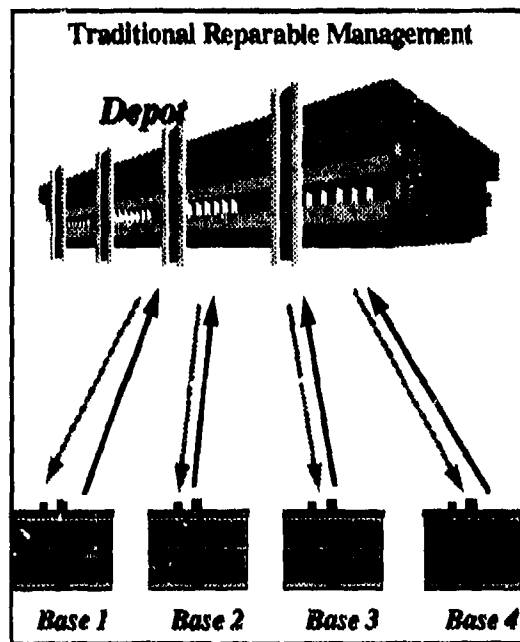
Figure 7. Traditional vs. LL Reparables Management.

Data Collection Strategies.

The design of a study is its plan for fulfilling the objectives and answering the questions of a study. When defining an experimental design, a researcher has many options in choosing tools for evaluating the problem and its potential solutions. The Lean Logistics concept basically re-engineers old methods of reparable item repair and transportation throughout the USAF pipeline. Therefore, a researcher must choose a method of evaluating the LL system that is best suited for its unique characteristics. The following section discusses several alternatives in evaluating this research, and briefly cites its validity or lack thereof to LL.

Survey. Surveying, in a fundamental sense, is questioning subjects and recording their responses for analysis. The primary strength of this technique is its versatility. Information of all types can be gathered through questioning-information such as opinions, attitudes, intentions, and expectations. Also, surveys tend to be efficient and economical in that a few carefully worded questions can quickly gather information that would take more time using another method of data collection. However, this technique has its drawbacks. The quality of information depends upon the respondent's willingness to cooperate. The respondent may not have the knowledge the researcher is seeking or may misinterpret the question.

Another potential problem with surveys is experimenter problems. An experimenter may ask the wrong questions, or be ambiguous about the exact nature of the information desired in a response. Further, an experimenter may ask questions in a biased manner, so that the respondent is coerced into a specific answer that is in line with a preconceived set of findings an experimenter wishes to show (Emory and Cooper, 1991:318-319).

Finally, the respondent may intentionally provide false information. A survey is most appropriately used in a situation where the respondent is uniquely qualified to provide the required information. Surveys can be performed by face to face interview, by telephone, by mail, or by some combination of these methods(Emory and Cooper, 1991:318-319). Surveying would not appear to be an extremely efficient method of evaluating the effects of LL on the current reparables pipeline, primarily because LL had not yet been implemented throughout the Air Force. As such, the only legitimate survey study that could be done at this point would be an analysis of people's opinions of LL implementation.

Observation. Observation can be thought of as the monitoring of non behavioral and behavioral activities. Non behavioral observation includes record analysis, physical condition analysis, and physical process analysis. Record analysis is one of the more prevalent forms of observation

34

research. It may involve historical, current, public, or private records. Physical condition analysis may include studies of plant safety compliance, or an analysis of inventory conditions. Physical process analysis may involve time/motion studies of a manufacturing process, traffic flow, paperwork flow, or information flow of various organizations or systems. Behavioral observation includes nonverbal analysis, linguistic analysis, extra linguistic analysis, and spatial analysis. Nonverbal behavior involves body movement and motor expressions. Examples of linguistic behavior observation are the study of a sales presentation content, how much information is conveyed in training session, or the interaction process that takes place between two people. Communication can also take place on an extra linguistic level. Extra linguistic activity includes voice, temporal, interaction, and verbal stylistic dimensions. Spatial analysis is the study of how persons relate physically to others, organize the territory around them, and how they maintain distances between themselves and others(Emory and Cooper, 1991:401-402).

The observational method of data collection has several advantages or strengths. For example, there are many types of information that can only be gathered through observation such as records and mechanical processes. An event can be recorded as it happens in its natural environment. Original data can be collected at the time it occurs. Information

35

that most participants would ignore can be collected such as dates, times, and locations. Finally, observation is less intrusive than questioning, producing less bias. Like other techniques, this method has its weaknesses. It is often difficult to predict where and when the event of interest will occur. Observation can be slow and expensive. Reliable results are limited to data directly monitored. The research environment is suited to subjective assessments in that exercise of controls may produce biases. Finally, observation is a limited way to learn about events that occurred in the past or at distant locations(Emory and Cooper, 1991:402-403).

Additionally, the relationship between the observer and the subject must be considered. This relationship can be viewed from three different perspectives: directness of observation, concealment, and participation. Direct observation is where the observer is physically present to monitor the event. Indirect observation is where recording is accomplished by mechanical, photographic, or electronic means. When the presence of the observer is known, there is a risk of atypical activity by the subjects. Concealment of the observer reduces this risk, but may bring up questions of ethics. Participation produces a dual demand on the observer. Participation may interfere with recording and recording may interfere with participation(Emory and Cooper, 1991:404-405). In evaluating the LL system, similar

36

problems exist with surveying and observation. The concepts

have not been fully developed or implemented, which makes it

extremely difficult to observe any kind of research data.

Experimentation. Simply stated, experiments are

studies that involve intervention by the researcher.

> Experiments are performed by investigators in virtually
> all fields of inquiry, usually to discover something
> about a particular process or system. Literally, an
> experiment is a test. A designed experiment is a test
> or series of tests in which purposeful changes are made
> to the input variables of a process or system so that
> we may observe and identify the reason for changes in
> the output response.(Montgomery, 1991:1)

Experimentation as a data collection method has several

strengths. This method comes closer than any other to

demonstrating causality-changes in one variable attributed

to changes in another. This stems from the researchers

ability to manipulate the independent variables.

Contamination from extraneous variables can be controlled

more effectively than with other methods. The convenience

and cost of an experiment can be superior to other methods.

Repeating the experiment under different conditions leads to

an average effect of the independent variable. However,

experimentation has its drawbacks. The artificial setting

of the laboratory is one of the primary disadvantages.

Generalization about population behavior derived from

behavior found in samples can pose problems(Emory and

Cooper, 1991:417-418). Experimentation would be a feasible

method of evaluating the LL system from the perspective that

37

it is not fully implemented, and the researcher could manipulate a specific scenario for examination. However, the researcher must take care in emulating the system the way it is intended, and not in a manner that makes it easy for study.

Simulation. In their book "Discrete-Event System Simulation," Banks and Carson cite several characteristics and advantages of using simulation as a research technique (see Figure 8).

1. Once a model is built, true experimental control can be exercised over the variables of interest.
2. The model can be easily altered by the experimenter, and experiments can be run repeatedly at low cost and high speed.
3. Simulation methods are easier to apply than analytical methods, and data collection is less difficult.
4. Analytical models require many simplifying assumptions; effects of variables cannot be controlled/measured.
5. When modeling unknown conditions, analytical models require extrapolation beyond the range of data; in these instances, simulation is often the only way to obtain data estimates under the proposed conditions of interest.
6. In some cases, simulation is the only analytical technique available to provide insight to the problem.

Figure 8. Advantages of Simulation as a Research Technique.

Simulation models are designed to imitate real-world situations to the extent that conclusions drawn about data collected are indicative of a given situation.

In its broadest sense, computer simulation is the process of designing a mathematical-logical model of a real system and experimenting with this model on a computer. Thus simulation encompasses a model building process as well as the design and implementation of an appropriate experiment involving that model. These experiments, or simulations, permit inferences to be drawn about systems
*   Without building them, if they are only proposed systems;

- Without disturbing them, if they are
  operating systems that are costly or
  unsafe to experiment with;
- Without destroying them, if the object of
  an experiment is to determine their limits
  of stress. (Pritsker, 1986)

In other words, the system described is simplified and
logically mapped. When evaluating a developmental system,
it is difficult to perform accurate analysis on the overall
system, primarily because all needed information is usually
not known. Lean Logistics is such a developmental system.
This research used historical data from existing reparables
databases and manipulated it through the use of pipeline
formulas to derive Lean Logistics levels.

In this study, historical demand activity and asset
stock levels could be determined relatively easily for the
desired time periods. However, asset transportation costs
as assigned on a per unit basis were not tracked in the
modern Air Force. Moreover, there is no historical data to
be obtained anywhere about the behavior of assets in the
reparable pipeline under the LL concept, mainly because it
has not actually been implemented yet. Several LL test
studies have been performed on various weapon systems at
various bases, but data from these tests can hardly be used
to represent general peacetime reparable asset activity.
This research is designed to review peacetime asset behavior
under both systems and compare the performance levels of
each (HQ AFMC Slide Package, 1994).

Current Requirements Computation Tools and Theories.

This research evaluated traditional and LL reparable asset activity in a simulated pipeline. Many tools and databases are maintained in today's Air Force that assist inventory managers in evaluating pipeline performance and help show needs for improvement. The following discussion provides a description of some of the tools and databases relevant to managing reparable assets for the B-1 in the current Air Force.

The Dyna-METRIC Model. The Dyna-METRIC model is a simulation tool used to assist AF personnel in determining assets needed to support a wartime or deployment scenario. This model analytically forecasts how asset support processes will affect wartime capability as measured by aircraft availability. Although Dyna-METRIC is primarily used for computing wartime flying needs and activity, a scenario can be established to assist in peacetime calculations. The data derived for this study were based upon peacetime activity (Isaacson and others, 1988:1-10).

Dyna-METRIC considers the activity of the shop replacement units (SRUs) that affect breakage or repair of line replacement units (LRUs). This research does not consider activity of the SRUs in the pipeline for simulation of repair and resupply, but Dyna-METRIC considered SRU activity to determine which assets were critical to

supporting the B-1. Dyna-METRIC identified twenty problem items for each location that maintained any B-1 aircraft. Criticality of assets was then averaged across all bases supporting the B-1 to determine which five assets were the most critical for the entire weapon system. Once the most critical assets were identified, the D041 database at HQ AFMC was queried for the information necessary for input into the simulation model used for this research(Isaacson and others, 1988:1-10).

The Recoverable Consumption Item Requirements System (D041) Database. The D041 database is used to compute annual reparable asset buys and repairs for peacetime, steady state Air Force flying activity. Steady state flying activity refers to the point in time in which flying activity remains relatively constant over time. The information in this system reflects peacetime activity. All needed stock number historical data was drawn from the D041 system for input into the simulation model used in this research. The following data element definitions were all drawn from Air Force Materiel Command Regulation 57-4, the Recoverable Consumption Item Requirements System (D041).

Administrative Lead Time Months: This number represents actual lead time months plus seven days converted back into months. Nine months is the maximum value allowed for this data element.

Production Lead Time Months: Represents actual contractor production time converted into months. The maximum value for this element is 99 months, and the minimum value is one month.

Pipeline Days: This consists of three elements: base order and shipping time days, base repair cycle days, and depot repair cycle days.

Order and Shipping Time Days (O&ST): This represents the authorized number of days worth of stock that has been approved on hand at the operating bases to cover the order and ship time pipeline days. It is the time span expressed in calendar days, from the date of the start of a requisition of a serviceable item until its receipt by the requesting activity.

Actual base O&ST days are averaged if there are five or more transactions within an eight quarter period of all stock numbers within the intermediate and substitute group. This means that if there are any transactions on the line replacement unit, any of its shop replacement units, or any applicable substitutes for either of these, the value will be calculated.

Base Repair Cycle Days: The authorized number of days worth of stock that has been approved to be on hand at the operating bases to cover the base repair cycle days. These days represent times, expressed in calendar days, from the date when an unserviceable item is removed from the weapon

43

system until it is made serviceable in base maintenance and is ready for reissue. Actual base repair cycle days are averaged if there are five or more transactions within an eight quarter period of all stock numbers within the intermediate and substitute group.

Depot Repair Cycle Days: The authorized peacetime number of days worth of stock that has been approved to be in the pipeline to cover stock returning to depot for repair action. These days represent the time, expressed in calendar days, from the time of removal of an unserviceable item from the weapon system on which it was installed, until the time the item is made serviceable through repair by organic or contractor overhaul facility.

Actual depot repair cycle days are averaged if there are five or more transactions within an eight quarter period of all stock numbers within the intermediate and substitute group. Depot repair cycle days consists of base processing days, reparable in-transit days, supply to maintenance days, shop flow days, and serviceable turn-in days.

Base Processing Days: Covers the time, in calendar days, from the time an item is removed from the weapon system, bench checked, processed through base supply, to the time it is ready for shipment.

Reparable Intransit Days: Covers the time, in calendar days, from the shipment by base supply to the receipt by the source of repair.

44

Supply to Maintenance Days: Covers the time, in calendar days, from the receipt of the unserviceable asset in depot supply to the maintenance shop's issue of a work order for the repair of an unserviceable item.

Shop Flow Days: Covers the time, in calendar days, normally required to repair an item, from the date the reparable is input for repair to the date of the serviceable output.

Serviceable Turn-In Days: Covers intransit time, in calendar days, that applies to the processing of serviceable items from the source of repair to supply.

Total Organizational and Intermediate Maintenance Demand Rate (TOIMDR): Represents the current quarter's total organizational and intermediate maintenance failures per 100 flying hours that occurred during operational use of an aircraft or system. The rate represents the number of base repairs plus the number of assets returned to depot plus base condemnations that have occurred.

Percent of Assets Repaired at Base (PBR): Self-explanatory.

Percent of Assets Not Repaired This Station (NRTS): The percent of assets returned to depot for repair.

Base Percent Condemned: The percent of assets condemned at base (only applies to assets that can be condemned at field level).

Depot Percent Condemned: The percent of assets condemned at depot.

Repair Cost: The average cost to repair a reparable item. This includes the cost of the shop replacement unit and other resources required to repair the item.

Inventory at Multiple Locations-The Square Root Rule. One of the general concepts of consumable item management is that when asset distribution is consolidated into one location, a smaller overall number of assets is required to support existing facilities given that demand rates remain constant. The square root rule can be shown as follows:

$$X_2 = X_1 \sqrt{n_1 / n_2}$$

where:

n_1 = the number of existing facilities,
n_2 = the number of future facilities,
X_1 = total inventory in existing facilities, and
X_2 = total inventory in future facilities.

Hill showed that consolidation of reparable assets can result in significant savings to the Air Force in the form of investment outlays (Hill, 1993). This may be argued by pointing out that reparable assets are managed differently than consumable assets in today's Air Force. Reparables are repaired and reused, while consumables are discarded. However, this research examines only the asset levels at the

46

base and intermediate supply points. Asset levels at the depot are treated as given and constant (Tersine, 1994).

Chapter Summary

The literature review covered several definitions of logistics and discussed how the concept of a pipeline is used to visualize the flow of assets through the logistics system. Discussion then summarized the acquisition, depot, base, and disposal pipeline subsystems and the intervening transportation segment, highlighting the flow of assets in each. The review then examined the goals, changes and desired outcomes proposed under the Lean Logistics concept and how the Theory of Constraints and Just-In-Time principles relate to LL. Finally, it provided an account of different data collection strategies and the use of simulation in modeling systems and how it applies to this study.

Overview of Chapter Three

Chapter Three begins with a discussion of the importance of the factors chosen for this study, followed by the specific hypotheses to be examined. It outlines the research design, to include the factors and levels of the independent and dependent variables involved in the research. Issues concerning population and sample selection

are iterated, followed by an in-depth review of the simulation design. The chapter concludes with notes on issues surrounding the non-parametric ANOVA tools used for statistical analysis of data.

III. METHODOLOGY

Introduction

This research compared Lean Logistics USAF reparable pipeline activities to those of the traditional USAF reparable pipeline to determine which performed better with respect to two dependent variables. The performance measures of interest were fully mission capable aircraft and transportation cost. This chapter reiterates the investigative questions identified in chapter one and explains their importance as individual elements to the overall study. It then delineates the specific hypotheses developed to help determine whether the Lean Logistics system would perform better than the current system with respect to the dependent variables. The methodology will allow the research to show whether Lean Logistics accomplishes its objectives in reducing costs and maintaining or improving the number of fully mission capable aircraft in a fleet.

The method used to perform this study was simulation. Chapter two briefly described the characteristics and advantages of simulation as a modeling tool. This chapter describes the simulation design and characteristics in detail.

Finally, this chapter describes the statistical evaluation methods that were used in the study. Due to the nature of the data, a nonparametric analysis of variance was

performed to test for significant differences between the means of 27 treatments. Nonparametric alternatives to paired-t testing were then performed to indicate the significance of the differences.

Importance of Factors to be Studied

Chapter 1 identified the investigative questions used to determine whether LL will be an improvement over the traditional pipeline. This section explains the reasons for posing each individual question and its importance to the overall study.

1. What are the specific effects on fully mission capable aircraft, within the context of the various treatments, of varying asset stock levels, transportation time, and depot repair time ? LL proposes that consolidating assets and reducing depot repair times and transportation times translates into reduced asset requirements in the overall system. The experiment varies these factors and measures affect fully mission capable aircraft at any given time and on average. The number of fully mission capable aircraft is one of the primary indicators that Air Force logisticians use in assessing the success of their operations.

2. What are the specific effects on the cost of transporting assets in the system, within the context of the

various experimental treatments, of varying asset stock levels, transportation time, and depot repair time? The importance of decreasing the number of assets held in warehouses is whether that asset reduction translates into a dollar savings, and the magnitude of the savings. Currently, headquarters AFMC personnel assert that LL propositions will result in a savings of $69 million in annual buy and repair requirements for reparable B-1 assets in fiscal year 1994. The $69 million figure represents a cost avoidance for buying assets to replace those condemned from the system. As a result, less assets will be needed in the overall system to maintain the current level of performance(HQ AFMC Slide Package, 1994).

The research provided answers to questions about current and LL pipeline performance with respect to fully mission capable aircraft and transportation cost. It also demonstrated system performance for numerous intermediate pipeline configurations between the current and LL configurations. These alternative pipeline configurations were developed by varying asset stock levels, depot repair time, and transportation time. The answers to these investigative questions also showed whether LL fulfilled its original intentions.

Specific Hypotheses

The hypotheses tested for each of the dependent variables is described here. The methods of statistical evaluation for each tested hypothesis are more thoroughly described in their own section of this chapter.

1. The first hypothesis tested relates to fully mission capable aircraft and reads as follows:

> Ho: Lean Logistics maintains the same or lower level of fully mission capable aircraft as the current reparables pipeline.

> Ha: Lean Logistics maintains a greater level of fully mission capable aircraft than the current reparables pipeline.

It is expected that LL will require a smaller number of reparables in the system in order to maintain the same level of fully mission capable aircraft. Quick analysis of current pipeline formulas (discussed later in this chapter) indicates that less items need to be stocked at a warehouse if the time it takes to order and receive a part is significantly reduced(Pohlen, 1994). Therefore, the outcome expected for the null hypothesis is rejection.

2. The second hypothesis relates to the transportation cost and is stated below:

> Ho: Lean Logistics requires the same or less of a transportation dollar investment than the current pipeline system.

52

Ha: Lean Logistics requires a greater transportation
dollar investment than the current pipeline system.

Again, the null hypothesis is expected to be rejected.
Transportation cost is expected to increase with the
implementation of Lean Logistics. Faster transportation
will cost more on a per unit basis and smaller inventories
of spare reparables at the retail level should also require
more frequent shipments. Therefore, it logically follows
that overall system transportation cost would be greater
under the LL philosophy.

Research Design

This research examined the effects of three independent
variables altered at three levels on two dependent
variables. Values for some variables were drawn from
existing Air Force databases, while others were derived to
suit the needs of the research. The following sections
describe the specifics of these variables, including the
manner in which they were computed.

Independent Variables. The independent variables
chosen for this study are transportation time, depot repair
time, and asset stock level.

Origin of Independent Variable Levels. Each of
these three variables was chosen because it represents a
major thrust of Lean Logistics. The research intended to
show how these main thrusts affected the reparables pipeline

with respect to fully mission capable aircraft and overall
transportation cost of items in the system. Table 3 outlines
the factors and levels analyzed in the research.

Table 3. Independent Variables and Treatment Levels.

Factor/ Treatment Level	HIGH	MEDIUM	LOW
Transportation Time	UMMIPS	Average of Current and LL Models	Lean Logistics Levels
Depot Repair Time	Current Model	Average of Current and LL Models	Lean Logistics Levels
Asset Stock Level	No Consolidation	Some Consolidation	Maximum Consolidation

Values for each of these factors were specifically
derived from reparable asset pipeline and stockage formulas
used in the management of today's Air Force reparables. The
values were also derived with the assistance of information
found in Lean Logistics point papers and the B-1 portion of
the D-041 database for both traditional and Lean Logistics
considerations. The following sections describe the
theories and formulas underlying the values used in the
initial conditions of the simulation model (D-041 Database,
1994).

Transportation Time Levels. Transportation time
was studied at three levels. The high level represents the
current logistics pipeline. This value was derived from the
UMMIPS standards (see chapter 2, Table 1) (AFM 67-1, 1986).
The low level represents the amount of time Lean Logistics

54

proposes as the standard order and ship time for CONUS

movement of reparable assets(HQ AFMC Slide Package, 1994).

The medium level of transportation cost is the average of

the high and low levels.

Traditional transportation levels were represented by

the UMMIPS standard of 22 days, and was standard across all

stock numbers. Again, traditional levels represented the

high treatment for the factor. Lean Logistics represented

the low level of treatment for the factor. The new theories

assert that transportation will only take one to two days

within the U.S. and three days for overseas shipments.

Therefore, the low level of treatment for transportation

became two days for all stock numbers. As with depot

repair times, the medium treatment of transportation times

was derived by averaging the high and low treatment levels

values(LL Slide Package, 1994). Table 4 shows these values,

and Figure 9 shows the locations of the bases and the depot

used in this study.
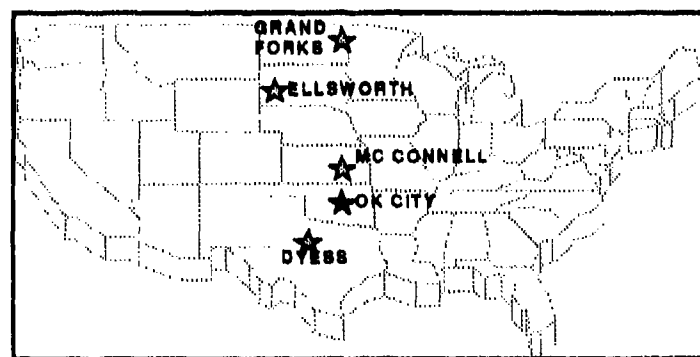
Figure 9. Base and Depot Locations

Depot Repair Time Levels. Traditional depot repair time levels were drawn from B-1 data in the March 1994 database(D-041 Database, 1994). Traditional levels represented the high level for this factor. Lean Logistics theories assert that eighty-five percent of the time that an asset requires for depot repair is queue time(LL Slide Package, 1994). Therefore, the low level of treatment was fifteen percent of the time that it takes for asset repair under theories of traditional pipeline management.

The medium treatment level was then established as an average of the high and low treatment levels. This medium level was inserted as a type of sensitivity analysis to show how responsive the outputs were to changes in depot repair times. Table 4 shows the various initial conditions used for the five stock numbers at each applicable level.

Table 4. Asset Depot Repair Cycle Times

NSN	Traditional Depot Repair Cycle Time	Medium Depot Repair Cycle Time	LL Depot Repair Cycle Time
6615 01 269 5439	51	31	10
6615 01 036 3198	21	13	4
6605 01 252 9480	53	32	11
6615 01 271 9168	23	14	5
6620 01 265 2887	46	28	9

Depot repair time is the same as the data element "depot repair cycle days" as defined in the D-041 database (see Chapter II).

The high level of depot repair time is the value for this data element as found in the D-041 database. For example, the D-041 database states that for an HML, it takes an average of 51 days to repair the asset. This value is unique to each stock number, but has been averaged across all B-1 bases(D-041 Database, 1994). Lean Logistics proposed reducing the average depot repair cycle time from 54 days to 10 days. This is an 81 percent reduction in repair time(HQ AFMC Slide Package, 1994). As such, the low level of treatment was averaged to 20 percent of the value used as the high treatment. Therefore, under the low level of treatment, the HML that traditionally would take 51 days to repair would theoretically take only 10 days to repair with the employment of LL practices. Again, the medium level of treatment is the average of the high and low treatments. Thus, the HML under this treatment takes an average of 31 days to repair. Table 7 thoroughly outlines the repair times used for each of the studied assets.

Asset Stock Levels. Asset stock levels were calculated using current USAF standard base supply system (SBSS)pipeline model formulas(Pohlen Notes, 1994). The high level represents the current number of assets in the system. Asset stock levels were calculated for base and depot for the high level of this factor. Medium asset stock levels were calculated using the same pipeline formulas and represent the asset distribution that will exist under LL

practices. Order and ship times and depot repair cycle times were altered in the calculations to derive the applicable values for base and intermediate supply point asset stock levels.

The lowest asset stock level is a unique approach to establishing reparable asset stock levels. Chapter two discusses the square root rule as it applies to consumable asset stockage. Although this research examines reparable asset behavior, a related study demonstrated that this consumable concept applied to reparable asset behavior could result in significant asset and investment reductions(Hill, 1993). Therefore, the square root rule was applied to asset stock levels at the intermediate supply point to derive the low level of asset stockage.

The levels of this factor were set with the assistance of the B-1 segment of the D-041 database. The following formula was used to calculate the needed pipeline quantity of assets (Pohlen Notes, 1994):

$$\textbf{\textit{Pipeline Stock}} = Q = ((DDR) \times (PBR) \times (RCT)) + ((DDR) \times (1-PBR) \times (OST)) + ((DDR) \times (1-PBR) \times (NCT))$$

where

DDR = Daily Demand Rate
PBR = Percent of Base Repair
RCT = Repair Cycle Time
OST = Order and Ship Time
NCT = Time required to determine the asset cannot be repaired at base.

The actual total base stock requirements (TSR) were then determined using the following formula:

$$TSR = Trunc(Q + \sqrt{3Q} + .5)$$

This formula for total stock requirement assumes an 85 percent stockage effectiveness and 95 percent fill rate of the asset for which the formula is applied (AFM 67-1, Vol II, Part Two:19-24). The theory behind these formulas also assumes that depot always has a serviceable asset on the shelf when a request is initiated. As such, retrograde asset shipment and depot repair times are assumed to be zero. It is for these reasons that the values derived from calculations are used to initialize the model(Pohlen Notes, 1994).

The various elements of the pipeline stock formula were gathered from historical data found in the March 1994 version of the D-041 database. The following sections describe how data was input into the formulas for each of the base asset stock levels and the intermediate asset stock levels.

Values derived from theoretical pipeline formulas were used for input into the simulation model for several reasons. First, it was impossible to obtain actual stock levels at the intermediate supply points because no actual ISPs have been established for the B-1 weapon system. Since

real data could not be obtained for each asset at each level (retail to wholesale) of stock, pipeline models were used to maintain consistency across the study.

The second reason pipeline formulas were used across all storage levels and assets is that these formulas imply a certain level of performance by translating to a given fill rate and stockage effectiveness expectation. The stock numbers selected for the study were the five most critical assets warehoused at Oklahoma City Air Logistics Center. The very fact that they were the most critical assets implies that they would not be able to maintain the desired effectiveness levels established in the pipeline formulas. Consequently, using the stock levels identified in the D-041 database would not provide researchers any insight as to the effectiveness level the D-041 figure provided. Therefore, pipeline formulas were used to establish stock levels at all warehouses to maintain consistency and an identifiable level of performance. Appendix A shows the numbers input into the model for each data element of each stock number.

Base Stock - Traditional Levels. These values were calculated from raw data found in the D-041 database. Asset demand rates for each base were calculated from the demand rate given in the D-041 multiplied by the number of flying hours for the base in question. Pipeline stock was then calculated for each base and used to

60

determine the total base stockage requirement(D-041
Database, 1994).

Table 5. Initial Conditions for Traditional Base Asset Stock Levels.

NSN	Dyess Base Stock Level	Ellsworth Base Stock Level	Grand Forks Base Stock Level	McConnell Base Stock Level
6615012695439	2	1	1	1
6615010363198	2	1	1	1
6605012529480	3	3	2	2
6615012719168	2	2	1	1
6620012652887	3	3	2	2

Base Stock - LL Levels. These values were
calculated by reducing the order and ship time for each
asset to one. Lean Logistics proposes that CONUS asset
movement will be either one or two days from depot, so the
model reflects such a change. (LL Slide Package, 1993)

Table 6. Initial Conditions for LL Base Asset Stock Levels.

NSN	Dyess Base Stock Level	Ellsworth Base Stock Level	Grand Forks Base Stock Level	McConnell Base Stock Level
6615012695439	1	1	1	1
6615010363198	1	1	1	1
6605012529480	2	1	1	1
6615012719168	1	1	1	1
6620012652887	2	2	1	1

ISP Stock - No Asset Consolidation. The
asset level derived for this intermediate stock level was
calculated through the use of the following formula:

$$MISP_{Med} = \sum_{n=1}^{4} (BSR_{Trad}) - \sum_{n=1}^{4} (BSR_{LL})$$

where

MISP = Medium Intermediate Stock Level
BSR_{Trad} = Traditional Base Stockage Requirements
BSR_{LL} = LL Base Stockage Requirements.

ISP Stock - Asset Consolidation. This level employed the use of the $\sqrt{N}$ rule. The section describing the theory behind the square root rule indicates the formula used to determine the level of asset consolidation possible. For the purposes of this research, the following formula was used:

$$MISP_{Low} = MISP_{Med} (\sqrt{1/4}) .$$

Tables 5 through 7 indicate the actual values determined for each of the stock levels at base and the intermediate supply point(Pohlen Notes, 1994).

Depot Stock. Depot stock levels were calculated by using a modified version of the formula used for base asset stock levels. The following formula was used to calculate depot pipeline quantities for each base (Pohlen Notes, 1994):

Pipeline Stock = Q = ((DDR) x (PBR) x (DRCT)) +
((DDR) x (1-PBR) x (OST)) + ((DDR) x (1-PBR) x (NCT))

where

DDR = Daily Demand Rate
PBR = Percent of Base Repair
DRCT = Depot Repair Cycle Time
OST = Order and Ship Time
NCT = Time required to determine the asset cannot be
repaired at base.

Pipeline quantities for each asset at each base were then

multiplied by the NRTS quantities and added across all bases

to derive the overall depot pipeline quantity.

$$Depot\ Q = \sum_{all\ bases} ((Base\ NRTS\ Rate) * (Base\ Q))$$

The depot pipeline quantity was then input into the formula

for total stock requirement in order to obtain the depot

stock level.

$$TSR = Trunc(Q + \sqrt{3Q} + .5)$$

Table 7 shows the values for initial depot conditions as

calculated from these formulas, as well as ISP medium and

low asset stock levels.

Table 7. Initial Conditions for ISP and Depot Asset Stock
Levels.

NSN	ISP Medium Stock Level	ISP Low Stock Level	Depot Stock Level
6615012695439	1	1	4
6615010363198	1	1	2
6605012529480	5	3	9
6615012719168	2	1	4
6620012652887	4	2	7

63

The high level for the asset consolidation factor only involved the use of traditional base asset stock levels. The medium treatment combined the LL base stock levels with the medium ISP stock levels. Low factor levels were established by warming up the model with LL base stock levels and low ISP stock levels.

Dependent Variables. The following sections describes the dependent variables of interest to this research.

Fully mission capable aircraft. Fully mission capable aircraft is an important indicator of the operational readiness of the fleet. For purposes of this research, a jet without a serviceable asset was assumed to be unavailable for flight. In order to calculate fully mission capable aircraft for this study, the number of assets available for flight was divided by the number of authorized aircraft. This calculation was tabulated over time, so that an average fully mission capable aircraft figure could be derived.

Transportation Cost. The overall cost of transporting assets in the system was measured for each treatment of the experiment. The cost to transport a needed asset within the system was expected to increase under the Lean Logistics concept. Express or overnight shipment costs more than standard shipment. However, it is possible that the increased transportation cost may be off-set by significant decreases in asset outlays. Currently, LL

personnel maintain that it would take twenty years of
shipping assets through fast transportation in order to
surpass the reduction in asset outlays that LL will affect
(HQ AFMC Slide Package, 1994).

For purposes of this study, per unit transportation
cost is dependent upon the amount of time taken to ship an
asset one way from the base to the depot or from the depot
to the base. Transportation costs were assigned for each of
the applicable levels, bases, and stock numbers.
Transportation personnel at Dyess Air Force Base quoted a
cost of $1.75 per pound for fast transportation.
Traditional transportation methods are assigned only 37
percent of that cost. Traditional per pound asset shipment
costs for were calculated using the following formula:

$$Cost_{trad} = (\$1.75(37\%))/\# \, miles \, to \, depot$$

The per pound per unit price of shipment for each asset was
then multiplied by the unit's weight and its distance from
the Oklahoma City depot. Table 8 shows the shipment cost
derived for each asset at each base under traditional
methods of calculation.

Table 8. Traditional Asset Shipment Cost Values.

NSN	Dyess	Ellsworth	Grand Forks	McConnell
6615 01 269 5439	12.95	77.70	77.70	18.13
6615 01 036 3198	20.72	124.32	124.32	29.01
6605 01 252 9480	25.25	151.52	151.52	35.35
6615 01 271 9168	15.60	93.63	93.63	21.85
6620 01 265 2887	21.37	128.21	128.21	29.91

Similarly, the formula used to calculate per pound LL transportation shipment costs was as follows:

$$Cost_{trsd} = (\$1.75)/\# \ miles \ to \ depot$$

Again, this figure is multiplied by the weight of the asset and its distance to depot in order to obtain the shipment cost used in the research. Table 9 shows the values calculated for shipment of assets using fast transportation as required by LL.

Table 9. LL Asset Shipment Cost Values.

NSN	Dyess	Ellsworth	Grand Forks	McConnell
6615 01 269 5439	35.00	210.00	210.00	49.00
6615 01 036 3198	56.00	336.00	336.00	78.40
6605 01 252 9480	68.25	409.50	409.50	95.55
6615 01 271 9168	42.18	253.05	253.05	59.05
6620 01 265 2887	57.75	346.50	346.50	80.85

Medium levels of asset shipment costs were derived by averaging the traditional and LL values. Table 10 shows these figures.

Table 10. Medium Level Asset Shipment Cost Values.

NSN	Dyess	Ellsworth	Grand Forks	McConnell
6615 01 269 5439	23.98	143.85	143.85	33.56
6615 01 036 3198	38.36	230.16	230.16	53.70
6605 01 252 9480	46.75	280.51	280.51	65.45
6615 01 271 9168	28.89	173.34	173.34	40.45
6620 01 265 2887	39.56	237.35	237.35	55.38

Population and Sampling Plan. The following section describes the population and samples used for collection of data in the research.

Population Selection. The population of items used in this study included all reparable assets found on the B-1 aircraft. Lean Logistics will not impose strict guidelines across all weapon systems, as each weapon system has unique characteristics that must be considered in its management. For example, some weapon systems are located at many bases throughout the Air Force, both CONUS and overseas. Some weapon systems employ the use of contract maintenance exclusively on their reparable assets and would not require an intermediate supply point for support.

This study sought a weapon system that would require an ISP and was limited in scope, primarily within the CONUS. The B-1 fulfilled these requirements in that its four locations were located in the CONUS. Given this, all the locations are likely to be supported by one ISP. Such a situation allows for thorough study of the entire weapon system via examination of activity at one ISP.

67

Sample Selection. The sample chosen for this study includes 5 reparable Line Replaceable Units (LRUs). The B-1 historical database for the last eight quarters was extracted from Headquarters Materiel Command computers and used to run the Dyna-METRIC model. The Dyna-METRIC runs produced a prioritized list of all reparable B-1 assets. The top five assets, based on criticality, and managed, repaired and stored by Oklahoma City Air Logistics Center (ALC) were chosen for the study. Assets were chosen from only one depot in order to minimize the complexity of the research. However, the assets chosen from Oklahoma City also were among the most critical of all reparables on the B-1 fleet.

Simulation Design. Since the LL concept was in its developmental stages, historical data on system performance did not exist. Therefore, the qualities of a simulation model were deemed to be well-suited to the requirements of this research. The lack of availability of intermediate supply point data, the ability to manipulate several variables within the model and determine outcomes, and the ability to show a causal relationship between the independent and dependent variables of the models led to choosing simulation as the research technique. Appendix B offers a fundamental pictorial view of the model used for this simulation. It also describes the step by step logic used in deriving the model.

68

The major time segments of the traditional reparable pipeline include depot maintenance, transfer of assets from the depot to base level, and transfer of assets in need of repair from the base to the depot. The newly proposed pipeline will include the depot maintenance function, transfer of assets to the intermediate supply point, transfer of serviceable assets from the intermediate supply point to the base, and transfer of assets in need of repair directly back to the depot.

A facet of creating a sound simulation model was to formulate solid and practical assumptions about the current supply system and the system to be used under Lean Logistics. In order to do this, only a manageable segment of the traditional and Lean Logistics pipelines was reviewed. This segment included fixed information about the pipeline leading from depot to the intermediate supply point, but did not specifically address detailed activity within the depot supply or maintenance functions.

In order to accomplish the objectives of the research, three independent variables were identified: transportation time, depot repair time, and asset stock level. The simulation was built to model aircraft demands, as well as requisition and asset flow. The focus was to build valid assumptions about the various segments of the pipeline and methods of demand data calculations.

69

Model Acceptability. Model acceptability refers to the extent to which the model satisfies the needs of the user. It is more important than model verification or validation, but can be defined in part in terms of the two issues(Kraus, 1994).

Validation. Model validation substantiates whether the model represents the system under consideration to the level of detail required. It establishes that the desired correspondence exists between the model and the real system (Pritsker, 1986:11).

> The concept of validation should be considered one of degree and not one of an either-or notion; it is not a binary decision variable where the model is valid or invalid. It is not at all certain that it is ever theoretically possible to establish if we have an absolutely valid model; even if we could, few managers would be willing to pay the price...As the degree of validity of the model increases, so too will its development cost. (Shannon, 1975:208)

Model validation generally falls into two broad areas: subjective and statistical validation techniques(Balci, 1989:67). The model used in this research was validated using a subjective technique known as face validation. Under this technique, "people knowledgeable about the system under study, based upon their estimates and intuition, subjectively compare model and system behaviors to judge whether the model and its results are reasonable"(Balci, 1989:68).

70

For this research, personnel from the Logistics Management Agency (LMA) were solicited for a face validation of the model. The LMA and RAND corporation of California are the primary agencies used in preliminary LL studies. LMA personnel are kept well aware of LL proposals and changes as they occur. These personnel also serve as the operations research experts to advise LL decision makers. The most frequent methodology used in their studies is simulation, so it was determined that these personnel were suitable for use in validating the model used for this research(Nicholson, 1994 and Lynch, 1994).

Verification. Model verification is "the process of establishing that the computer program executes as intended" (Pritsker, 1986:11). Where validation deals with building the right model to accurately represent the system, verification deals more with translating the validated model into executable code with sufficient accuracy. The various techniques for simulation model verification can be classified into six categories: informal, static, dynamic, symbolic, constraint, and formal analysis. The level of mathematical formality and complexity of these verification techniques increases as one progresses from the informal to the formal analyses (Whitner and Balci, 1989:559).

The simulation model used in this research was verified using an informal analysis technique. This type of analysis

technique is one of the most common verification approaches. It is called informal because of the heavy reliance on human reasoning and subjectivity without strict mathematical formality - not due to a lack of structure or guidelines. Informal analysis techniques typically are not difficult to perform and require very little computer resources. The particular informal analysis technique utilized to verify the model used in this research was the desk checking method. Desk checking is performed as the model is developed and before the model is tested. Additionally, independent parties were involved to enhance the reliability and completeness of the technique (Whitner and Balci, 1989:561-562).

In addition to the informal analysis, a dynamic analysis was performed to further verify the simulation model used in this research. "Verification by dynamic analysis is accomplished by evaluating the model during its execution. As the model is exercised, its behavior is observed and information about its execution gathered" (Whitner and Balci, 1989:563). It can provide conclusive proof that the model works as intended. The particular dynamic analysis used to further verify the model used in this research was the bottom-up testing method. In bottom-up testing, as each submodel or module is built, it is thoroughly tested. After the submodels or modules have been tested, they are integrated and tested again. This process

continues until the complete model has been integrated and tested (Whitner and Balci, 1989:563-564).

For this research, the model was built for five stock numbers at four B-1 bases. During verification, the model was tested one segment at a time. For example, a gate mechanism was used in modeling to allow requisitions to be processed. One of the first tests performed was done to determine if the gate mechanism worked properly. Then, the model was elaborated to include activity for one stock number at one base. Once that portion of the model worked as intended, information for all five stock numbers at one base were input. Output was generated on this segment of the model and decoding was performed until this portion of the model worked well.

Finally, activity for all five stock numbers at all five bases was simulated. Test output was gathered and analyzed, and then the actual model used for this research was finalized. The activities described above were performed with the assistance of LMA and Air Force Institute of Technology staff personnel. Their expertise in the field and in simulation modeling was paramount to building a sound model for this study (Nicholson, 1994, and Kraus, 1994).

Initial Conditions. Initial conditions of the model refer to the values that are input into the model at the start of the simulation. Most values are derived from historical data collected through existing logistics

programs. However, since LL is a new concept, existing
theoretical models were used in some cases to generate
potential starting points. The three main factors that were
varied in the model were depot repair cycle time,
transportation time, and asset stock level.

Steady State Behavior. Most simulation models are
run with the goal of studying steady state conditions. "By
equilibrium or steady-state, we mean a condition of
regularity or stability in which opposing forces or
influences are balanced." (Shannon, 1975:183). However, in
most stochastic models there is a period of transient
behavior resulting from the effects of the initial
conditions. The challenge is to reduce the bias introduced
by the initial conditions. There are at least three ways to
decrease the initial bias:

> 1. Use long enough computer runs so that the data from
> the transient period are insignificant relative to the
> data from the steady-state condition.
>
> 2. Throw out or exclude some appropriate part of the
> initial period of the run from our considerations.
>
> 3. Choose initial starting conditions that are more
> typical of the steady-state condition and thus reduce
> the transient period. (Shannon, 1975:182)

For the purposes of this research, both options two and
three were used. Initial starting conditions that were
typical of steady-state conditions were derived as outlined
in the previous section and input into the simulation model.

74

Two methods were then used together to determine when
equilibrium had been achieved. First, the pipeline model
was run for three simulated years so that output measurement
data could be gathered and charted in time series plots.
Moving averages of estimated fully mission capable aircraft
were collected at ten day intervals over three simulated
years. The point in the time series plots where a
particular measurement's moving average no longer changed
significantly over time marked the end of the transient
period. Figure 10 displays the time series plot.
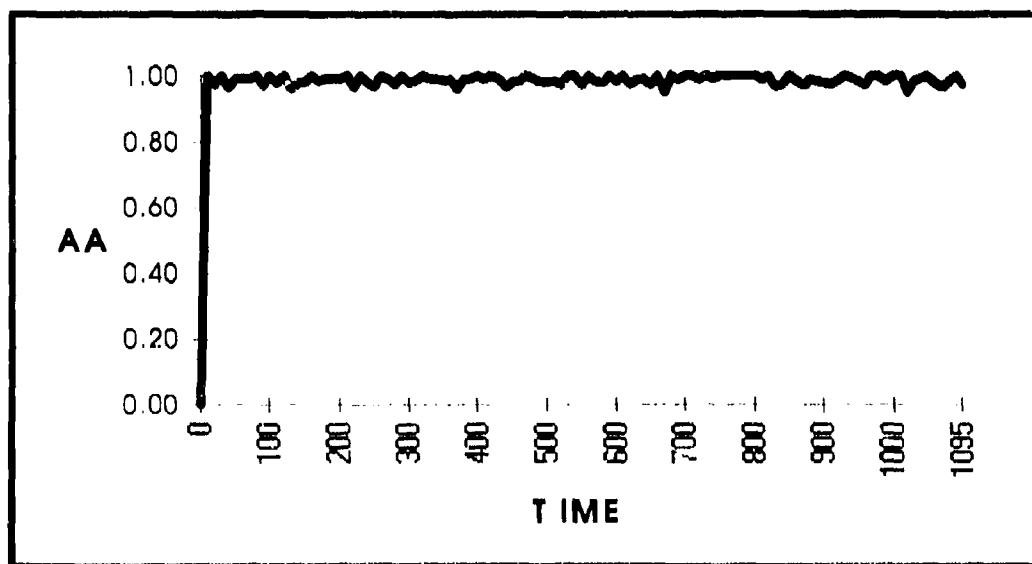
**Figure 10. Time Series Plot of Estimated Fully Mission
Capable Aircraft Moving Averages**

A visual check of the time series plots showed that the data
values stabilized within one year. An additional safety

factor of two was employed to ensure that initial bias did not affect the collection of data.

To provide rigorous support for the first method of determining when equilibrium had been achieved, an auto-correlation procedure was used to create an auto-correlation plot for the same measure of performance (estimated fully mission capable aircraft). Under this method, the longest period in which the data are significantly correlated is calculated and then deleted from the beginning of each run. The same data points used to create the time series plot were used to create the autocorrelation plots at a 95% confidence interval. Figure 11 shows the autocorrelation plot.

```
            -1.0 -0.8 -0.6 -0.4 -0.2  0.0  0.2  0.4  0.6  0.8  1.0
LAG   CORR.  +----+----+----+----+----+----+----+----+----+----+
 1   -0.016                          >    *    <
 2    0.014                          >    *    <
 3   -0.013                          >    *    <
 4    0.022                          >    **   <
 5   -0.002                          >    *    <
 6   -0.005                          >    *    <
 7   -0.001                          >    *    <
 8   -0.014                          >    *    <
 9    0.018                          >    *    <
10   -0.016                          >    *    <
11    0.008                          >    *    <
12   -0.013                          >    *    <
13    0.026                          >    **   <
14    0.005                          >    *    <
15    0.009                          >    *    <
```

Figure 11. Autocorrelation Plot of Estimated Fully Mission Capable Aircraft

The autocorrelation plot shows that for the worst case the series becomes stationary very quickly. This supports

the first method of using a visual check on the time series plot of moving averages and adding a safety factor to ensure that data was collected from an equilibrium condition. Statistical arrays were cleared at the two year mark of each simulation run.

Number of Replications. "Perhaps the most important decision faced by the analyst is to determine the size of the sample."(McClave and Benson, 1991:318). If the variance is unknown, a useful approach is to run a pilot study to collect an estimate of the variance and then compute the total number of observations required(Shannon, 1975:189).

For the purposes of this research, each treatment of the pipeline model was run for three simulated years for thirty replications during the pilot study. The data obtained during the initial two simulated year transient period was discarded as discussed in the previous section. Additionally, common random number seeds were utilized for each replication across treatments to minimize the introduction of unnecessary variance.

After a preliminary sample was taken from the pilot study, the necessary number of observations was calculated for the performance measure of estimated fully mission capable aircraft at each treatment using the following formula:

$$n = \frac{t^2 s^2}{d^2}$$

where

> t = tabulated t value for the desired
> confidence level and the degrees of freedom
> of the initial sample
>
> d = the half-width of the desired confidence
> interval
>
> s^2 = the estimate of the variance obtained in
> the sample or pilot run. (Shannon, 1975:189)

The largest number of replications for the various

performance measures and different treatments was calculated

to be 6.9285, which was well below the 30 replications

performed for data collection.

Statistical Analysis Tools Used

A researcher must decide what kinds of testing

procedures to use on the data that has been collected.

Classical or parametric procedures may be used or the

researcher may choose to use nonparametric procedures.   The

basic assumptions underlying the parametric testing

procedures are that

> 1) Each of the probability distributions is normal.
> 2) Each probability distribution has the same variance
> (standard deviation).
> 3)   The observations for each factor level are random
> observations from the corresponding probability
> distribution and are independent of the observations
> for any other factor level. (Neter and Wasserman,
> 1974:426)

78

These classical procedures require stringent adherence to the above assumptions and are valid only if these assumptions hold(Berenson and Levine, 1989:511).

When the classical methods of testing are not applicable, non-parametric methods can be used (Berenson and Levine, 1989:511). In recent years strong efforts have been made to develop these robust techniques. These non-parametric testing methods work well for a large variety of population distributions (Snedecor and Cochran, 1980:135). They also have many advantages, some of which are as follows:

> 1. Non-parametric methods may be used on all types of data - qualitative data (nominal scaling), data in rank form (ordinal scaling), as well as data that have been measured more precisely (interval or ratio scaling).
> 2. Non-parametric methods make fewer, less stringent assumptions (which are more easily met) than do the classical procedures. Hence, they enjoy wider applicability and yield a more general, broad-based set of conclusions.
> 3. Depending on the particular procedure selected, non-parametric methods may be equally (or almost) as powerful as the classical procedure when the assumptions of the latter are met, and when they are not met may be quite a bit more powerful. (Berenson and Levine, 1989:513)

To determine which method of testing to use, parametric or non-parametric, the data collected from the experiment must be tested to ascertain whether it conforms to the assumptions underlying the classical procedures.

Test for Normality. The Wilk-Shapiro/Rankit Plot was utilized to test the collected data for normality. This procedure produces a rankit plot of the variable and the Shapiro-Francia statistic is calculated. "Systematic departure of the rankit plot from a linear trend indicates non-normality, as does a small value for the Wilk-Shapiro statistic." (*Statistix*, 1992:247). The rankit plots for the data collected during this experiment was found to depart from a linear trend and, therefore, exhibits non-normality. The rankit plots can be seen in Appendix D.

Kruskal-Wallis One-Way Analysis of Variance. Since the data populations were shown to be non-normal, the F test was inappropriate. "One possibility then is to use the Kruskal-Wallis test based on the ranks of the observations." (Neter and Wasserman, 1974:520). The Kruskal-Wallis One-Way Analysis of Variance is a non-parametric test that tests for differences among the means of several groups (*Statistix*, 1992:106). The null hypothesis is that the mean is the same for each of the groups. Additionally, when five or more samples are taken for each group, the Kruskal-Wallis statistic approximates a χ^2 random variable. If the Kruskal-Wallis statistic is greater than the χ^2, the null hypothesis is rejected (Neter and Wasserman, 1974:520).

Statistix also provides a mean rank for each group, or for this research each treatment. The data was then sorted

based on the mean ranks of the treatments and the different treatments.

Rank-Sum Test. When two independent random samples are to be used to compare two populations, and the *t* statistic is inappropriate for making the comparison, the Rank Sum test can be used to test the hypothesis that the probability distributions associated with the two populations are equivalent. The test statistic is based on the total of the ranks of the two samples, the rank sums. If the two rank sums are nearly equal, this implies that the distributions that the samples were drawn from are the same. If the two rank sums are very different, this implies that the distributions that the samples were drawn from are different (McClave and Benson, 1991:954-955). For the purposes of this research, the two sample sizes exceeded the standard tables so the following formulas were used:

$$Z = (|\mu - T| - 0.5) / \sigma$$

where

$$\mu = n_1(n_1 + n_2 + 1)/2 \text{ and } \sigma = \sqrt{n_2 \mu / 6}$$

For this research, μ was calculated to be 915 and σ was calculated to be 67.64 for both fully mission capable aircraft and transportation cost.

Chapter Summary

81

This chapter discussed the importance of the factors studied in the research, followed by the specific hypotheses posed on these factors. It outlined the research design, including the specific variables studied and their importance. Factors and levels of the variables studied were discussed, followed by detailing of research population and sample considerations. Simulation design was explained, to include information on the length and number of simulation runs. Finally, the chapter gave a brief overview of the statistical analysis tools used for the research.

Overview of Chapter Four

Chapter four discusses the findings and analysis of model outputs. It begins with a description of the outcome of the methodology and then details data findings and analysis.

IV. *Results and Analysis*

Introduction

This chapter presents the results and analysis of the data collected using the methodology described in Chapter III. First, confounds to the research are discussed, then the results of the experiment are presented in chart format. The next section of the chapter is arranged according to the investigative questions presented in Chapter I. Within this second section, the first area of analysis to be discussed is the effects of the different treatments of asset stock level, depot repair time, and transportation time on fully mission capable aircraft. Then the analysis involved with testing the related hypothesis is shown followed by an exploratory analysis. Next, a similar discussion concerning transportation cost is presented. Finally, the chapter concludes with a summary of results of the two areas of inquiry.

Confounds to Research

After the simulation model had been run through all its replications for the various treatments, the data was found to suffer from non-normality and non-homogeneity of variances. As discussed in Chapter III, these characteristics called for an analysis through the use of non-parametric methods. The non-parametric forms of

analysis are generally considered to be less powerful than the standard parametric procedures.

Due to the use of non-parametric analysis, the investigative questions stated in Chapter I could not be directly answered. Specifically, a parametric general analysis of variance would have allowed the dependent variables to be analyzed in terms of each independent variable and would have addressed interaction effects. Unfortunately, the non-parametric Kruskal-Wallis One-Way analysis of variance could only be used to analyze the dependent variables in terms of one factor. It was decided to analyze the dependent variables in terms of the various treatments because the treatments represented different combinations of the independent variables.

Data Collection Outcome

After the simulation model had been run through all the replications for the various treatments, the data was organized according to treatment and performance measure. The data from the experiment is summarized below in Table 11.

Table 11. Simulation Output Data Treatment Means

TREATMENTS	AA MEAN	AA STDV	TC MEAN	TC STDV
HHH	96.64	0.19	68685.26	2461.28
HHM	97.69	0.08	128054.50	3688.46
HHL	98.20	0.05	186369.68	4614.21
HMH	98.20	1.41	68178.98	2197.92
HMM	97.65	0.12	128412.18	3322.49
HML	98.13	0.06	182856.93	5333.20
HLH	95.00	0.39	69309.51	2517.59
HLM	97.80	0.05	127694.19	3901.01
HLL	98.17	0.07	183778.78	6540.17
MHH	94.36	0.25	68371.60	1892.86
MHM	96.56	0.16	128715.01	3214.15
MHL	98.14	0.06	184980.42	3743.41
MMH	94.83	0.19	68380.68	1987.78
MMM	96.84	0.12	128880.17	4835.25
MML	97.87	0.06	183375.68	5741.05
MLH	94.36	0.25	68371.60	1892.86
MLM	96.88	0.08	129255.90	4546.95
MLL	97.91	0.06	180638.80	5805.20
LHH	93.68	0.34	68649.69	1734.24
LHM	96.32	0.14	127637.07	3483.32
LHL	98.15	0.05	185192.96	4159.13
LMH	94.27	0.28	68852.76	2115.41
LMM	96.84	0.11	125322.67	3183.16
LML	97.62	0.08	183325.72	5353.70
LLH	95.00	0.39	69309.51	2517.59
LLM	96.86	0.09	129162.24	3547.96
LLL	97.91	0.06	180638.80	5805.20

Table 11 condensed the data points corresponding to the thirty replications for each treatment to a single mean value and standard deviation for each performance measure. The actual 810 data points for each performance measure can be found in Appendix E. The next section of the chapter is arranged according to the investigative questions presented in Chapter I.

Fully Mission Capable Aircraft

Investigative Question 1. What are the specific
effects on fully mission capable aircraft, within the
context of the various treatments, of varying asset stock
level, transportation time, and depot repair time?

The non-parametric Kruskal-Wallis One-Way ANOVA was
used to rank the performance of the various treatments with
respect to fully mission capable aircraft. For the purposes
of this research, the χ^2 value was determined to be 42.56
for an α of 0.05 and 29 degrees of freedom. (Neter and
Wasserman, 1974:807) Upon running the Kruskal-Wallis
procedure, the Kruskal-Wallis statistic for fully mission
capable aircraft was computed to have a value of 721.5.
Clearly, the null hypothesis can be rejected. There is at
least one treatment whose distribution is not the same as
the others. Table 12 shows the initial results of running
the Kruskal-Wallis ANOVA. The statistical analysis for this
test can be seen in Appendix F.

Related Hypothesis.

Ho: Lean Logistics maintains the same or lower level
of fully mission capable aircraft as the current
reparable pipeline.

Ha: Lean Logistics maintains a greater level of fully
mission capable aircraft than the current reparables
pipeline.

86

Table 12. KW Treatment Mean Ranks for Fully Mission Capable Aircraft.

Treatment	Mean Rank AA
LHL	690.20
MHL	686.80
HLL	680.00
MML	677.40
LML	668.40
HML	667.90
LLL	652.80
MLL	652.80
LLM	419.10
MLM	417.60
MMM	414.20
MHM	411.60
HMM	411.10
HLM	404.80
LHM	400.80
HHL	399.50
HHM	399.50
LMM	370.90
LLH	142.90
HLH	142.90
LMH	142.50
LHH	139.40
HHH	134.40
MMH	134.20
MLH	128.40
MHH	128.40
HMH	126.60

The Rank Sum Test was used to test if the fully mission capable aircraft distributions for the treatments representing the current reparables pipeline (HHH) and the

87

пипeline (MLL) differed. The statistical analysis is shown below in Figure 12.

```
STATISTIX 4.0                                    08/17/94, 20:40

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR AA BY TRT

                     SAMPLE
        TRT      RANK SUM   SIZE     U STAT    MEAN RANK
    ----------  ---------  ------   --------   ---------
    HHH           465.00     30      0.0000      15.5
    MLL           1365.0     30     900.00       45.5
    TOTAL         1830.0     60

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION      6.646
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION          0.0000

TOTAL NUMBER OF VALUES THAT WERE TIED        53
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60      MISSING CASES 0
```

Figure 12. Rank Sum Test for Current Reparables Pipeline and LL Fully Mission Capable Aircraft

The Z-value for this test was computed to be 6.645. Therefore, the null hypothesis of this Rank Sum test was rejected, meaning that the two distributions are different.

Exploratory Analysis. After the mean ranks for each treatment were obtained from the Kruskal-Wallis One-Way AOV, the treatments were sorted by their mean ranks in descending order. This was done as an exploratory analysis to help focus future research. Conclusions cannot be drawn from this particular analysis. The Rank Sum test was performed between the adjacent treatments to determine if the differences in distributions were significant within the 95

88

percent confidence interval. Table 13 shows the results of
the Rank Sum tests. This table suggests that there are many
adjacent treatments whose distributions for fully mission
capable aircraft are statistically different, as indicated
by the asterisks.

Table 13. **Rank Sum Test Results for Fully Mission Capable Aircraft.**

Treatment Pairs	Rank	Observed Z-value	Significant Differences
LHL MHL	851.5	0.9314	
MHL HLL	786.5	1.8923	*
HLL MML	627.5	4.2430	*
MML LML	870.5	0.6505	
LML HML	670.0	3.6147	*
HML LLL	652.5	3.8734	*
LLL MLL	915.0	-0.0073	
MLL LLM	465.0	6.6454	*
LLM MLM	764.0	2.2250	*
MLM MMM	873.5	0.6061	
MMM MHM	726.0	2.7868	*
MHM HMM	475.0	6.4976	*
HMM HLM	786.0	1.8997	*
HLM LHM	465.0	6.6454	*
LHM HHL	465.0	6.6454	*
HHL HHM	480.0	6.4237	*
HHM LMM	479.5	6.4311	*
LMM LLH	477.5	6.4606	*
LLH HLH	915.0	-0.0073	
HLH LMH	646.5	3.9621	*
LMH LHH	793.0	1.7962	*
LHH HHH	469.5	6.5789	*
HHH MMH	512.5	5.9432	*
MMH MLH	724.5	2.8089	*
MLH MHH	915.0	-0.0073	
MHH HMH	486.0	6.3350	*

Transportation Cost

This section reviews the findings for the second investigative question of this research.

Investigative Question 2. What are the specific effects on the cost of transporting the assets in the system, within the context of the various treatments, of varying asset stock level, transportation time, and depot repair time?

The non-parametric Kruskal-Wallis One-Way ANOVA was used to test the performance of the various treatments with respect to transportation cost. For the purposes of this research, the χ^2 value was determined to be 42.56 for an α of 0.05 and 29 degrees of freedom. (Neter and Wasserman, 1974:807) Upon running the Kruskal-Wallis procedure, the Kruskal-Wallis statistic for transportation cost was computed to have a value of 721.5. Clearly, the null hypothesis can be rejected. There is at least one treatment whose distribution in no the same as the others. Table 14 shows the initial results of running the Kruskal-Wallis ANOVA. The statistical analysis for this test can be seen in Appendix F.

Table 14. KW Treatment Mean Ranks for Transportation Costs.

Treatment	Mean Rank AA
HMH	126.6
MHH	128.4
MLH	128.4
MMH	134.2
HHH	134.4
LHH	139.4
LMH	142.5
HLH	142.9
LLH	142.9
LMM	370.9
HHM	399.5
LHM	400.8
HLM	404.8
HMM	411.1
MHM	411.6
MMM	414.2
MLM	417.6
LLM	419.1
LLL	652.8
MLL	652.8
HML	667.9
LML	668.4
MML	667.4
HLL	680.0
MHL	686.8
LHL	690.2
HHL	703.3

Related Hypothesis.

Ho: Lean Logistics requires the same or less of a transportation dollar investment than the current pipeline system.

Ha: Lean Logistics requires a greater transportation dollar investment than the current pipeline system.

The Rank Sum test was used to test if the transportation cost distributions for the treatments representing the current reparables pipeline (HHH) and the LL pipeline (MLL) differed. The statistical analysis is shown below in Figure 13.

```
STATISTIX 4.0                            08/17/94, 20:39

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

                          SAMPLE
  TRT       RANK SUM      SIZE     U STAT    MEAN RANK
-----------  ----------  ------  ----------  ----------
HHH            465.00       30     0.0000       15.5
MLL            1365.0       30     900.00       45.5
TOTAL          1830.0       60

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION      6.646
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION          0.0000

TOTAL NUMBER OF VALUES THAT WERE TIED            0
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60     MISSING CASES 0
```

Figure 13. Rank Sum Test for Current Reparables Pipeline and LL Transportation Cost

The Z-value for this test was computed to be 6.645. Therefore, the null hypothesis of this rank sum test was rejected, meaning that the two distributions are different.

Exploratory Analysis. After the mean ranks for each treatment were obtained from the Kruskal-Wallis One-Way AOV, the treatments were sorted by their mean ranks in ascending order. This was done as an exploratory analysis to help focus future research. Conclusions cannot be drawn from this particular analysis. The rank sum test was then performed between the adjacent treatments to determine if the differences in distributions were significant within the 95 percent confidence interval. Table 15 shows the results of the Rank-sum tests.

This table shows that there are relatively few adjacent treatments whose distributions for transportation cost are statistically different, as indicated by the asterisks. The analysis suggests that there may be three groupings of transportation cost. The treatments within these three groups may no be statistically different as far as transportation cost is concerned. The statistical analysis for these tests can be seen in appendix F.

Table 15. Rank Sum Test Results for Transportation Cost.

TREATMENTS	RANK SUM	Z	SIGNIFICANT DIFFERENCES
HMH MHH	909	0.081312833	
MHH MLH	915	-0.00739208	
MLH MMH	886	0.421348315	
MMH HHH	910	0.066528681	
HHH LHH	911	0.05174453	
LHH LMH	904	0.15523359	
LMH HLH	909	0.081312833	
HLH LLH	915	-0.00739208	
LLH LMM	465	6.64547605	*
LMM HHM	808	1.574512123	
HHM LHM	914	0.007392076	
LHM HLM	907	0.110881135	
HLM HMM	898	0.243938498	
HMM MHM	914	0.007392076	
MHM MMM	905	0.140449438	
MMM MLM	905	0.140449438	
MLM LLM	914	0.007392076	
LLM LLL	465	6.64547605	*
LLL MLL	915	-0.00739208	
MLL HML	863	0.761383797	
HML LML	908	0.096096984	
LML MML	876.5	0.561797753	
MML HLL	900	0.214370195	
HLL MHL	898	0.243938498	
MHL LHL	896	0.273506801	
LHL HHL	860	0.805736251	

Chapter Summary

This chapter presented the results and analysis of the
data collected using the methodology described in Chapter
III. First, confounds to the research were discussed and
the results of the experiment were presented. Then the
effects of the different treatments of asset stock level,
depot repair time, and transportation time on fully mission

capable aircraft were tested. Next, the test of the related

hypothesis was shown followed by an exploratory analysis.

Finally, a similar discussion concerning transportation

cost was presented.

Overview of Chapter Five

The next chapter begins with an interpretation of the

findings of the research and continues by evaluating those

findings with respect to statistical and practical

considerations. Next, the cost of operating such systems is

outlined for varying degrees of asset stock level and

transportation time. The chapter then identifies several

options for further research, followed by a thesis summary.

V. Conclusions and Recommendations

Introduction

This chapter discusses the conclusions drawn from the research. First, the findings are summarized and then interpreted from a management perspective. Finally, recommendations for future research are presented.

Summary of Findings

This section examines the results of the specific hypotheses that the research intended to answer.

Fully Mission Capable Aircraft. It was hypothesized that the treatment representing LL (MLL) would provide a higher percentage of fully mission capable aircraft than the treatment representing the current reparables pipeline (HHH). In order to compare the HHH and MLL treatments from a statistical perspective, the Rank Sum test was applied and the null hypothesis for the Rank Sum procedure was rejected. The distributions for fully mission capable aircraft from the two treatments were found to be statistically different.

Transportation Cost. It was hypothesized that the treatment representing LL (MLL) would provide a higher transportation cost than the treatment representing the current reparables pipeline (HHH). In order to compare the HHH and MLL treatments from a statistical perspective, the Rank Sum test was applied and the null hypothesis for the Rank Sum procedure was rejected. The distributions for

transportation cost of the two treatments were also found to be statistically different.

Interpretation of Findings

Fully Mission Capable Aircraft. Now that a statistical difference between the treatment means had been established, it was necessary to interpret this difference into useful information for a logistics manager. Recall from Chapter IV that the LL treatment mean for fully mission capable aircraft was 97.91 percent, which was higher than the current reparables pipeline treatment mean of 96.64 percent. Out of a fleet of 84 aircraft, this difference of 1.27 percent represents one additional fully mission capable (FMC) aircraft available under LL policies.

One additional FMC aircraft is certainly of significance to an aircraft manager located at any one of the bases considered in this research. For example, at Grand Forks, one additional FMC aircraft translates to an increase in their mission capable rate of 6.25 percent. This could represent quite an increase in combat capability. Based solely on the improved FMC percentage, all other things equal, Lean Logistics is the preferable reparables pipeline configuration.

Transportation Cost. Since a statistical difference between the treatment means has been established, it is necessary to interpret this difference into useful

information for a logistics manager. Recall from Chapter IV that the LL treatment mean for transportation cost was $180,638.80, which was much higher than the current reparables pipeline treatment mean of $68,685.26. The LL treatment mean for transportation cost was more than twice that of the current reparables pipeline. Based solely on transportation cost, it would seen that the current reparables pipeline is preferable to LL.

However, an exploration of the cost trade-off between asset consolidation and reduced transportation times for the various treatments is worthwhile at this point. Table 16 show an estimated cost to operate the various treatments studied in this research. Note that only the asset stock level and transportation time factors were considered. Depot repair time, although varied, did not have a direct impact on the number of assets in the system or the cost of transporting those assets.

Table 16.   System Cost Analysis.

TRTMT	TRANS COST	ASSET COST	TOTAL COST
H X H	068,678.84	10,025,963.52	10,094,642.36
H X M	128,125.99	10,025,963.52	10,154,089.51
H X L	183,461.97	10,025,963.52	*10,209,425.49*
M X H	068,678.84	10,025,963.52	10,094,642.36
M X M	042,251.87	10,025,963.52	10,068,215.39
M X L	183,461.97	10,025,963.52	10,209,425.49
L X H	068,678.84	09,045,377.37	*09,114,056.21*
L X M	128,125.99	09,045,377.37	09,173,503.36
L X L	183,461.97	09,045,377.37	09,228,839.34

The differences in transportation cost are tremendously demagnified when overall asset cost is considered. In other words, the research reflects a given level of FMC aircraft and the investment cost of having enough asset on the shelves to support that performance level.

Although the capability was built into the simulation model, asset condemnation activity was not used. The database used for information contained within the model listed condemnation rates for all B-1 line replaceable units to be zero. In order to draw conclusions about cost trade-offs between the LL and traditional systems, the required annual investments for transportation and asset outlays should be compared. In other words, the additional cost of assets requiring replacement due to condemnation from the system should be compared to the differences in the applicable transportation costs. Reference Table 16. The difference between the H X H and M X L transportation time treatments is approximately $115,000 per year. Therefore, if more than $115,000 in assets require replacement each year, then the LL system would cost less per annum than LL.

Recommendations for Further Research

There are abundant possibilities for further research concerning comparisons of Lean Logistics and current reparables pipeline operations, a few of which are outlined below.

As a direct extension of this thesis, research could be performed to group treatments with fully mission capable aircraft treatment means that are not statistically different. For example, if the grouping with the highest FMC aircraft mean consisted of five different treatments, cost analysis could be performed to determine which treatment would be the least expensive to operate. This treatment would be the preferred pipeline configuration since it provided the highest fully mission capable aircraft percentage for the least cost.

For this future research option, the same experimental design could be utilized with the same independent and dependent variables. Additionally, the same simulation model could be run through many more replications per treatment. This larger number of samples may help to reduce the problems experienced in this research with normality and equality of variance.

As suggested in a previous section of this chapter, the number of reparables requiring replacement due to condemnations during the year may play an important role in determining whether it is cost effective to adopt a pipeline configuration such as LL. It may be beneficial to evaluate LL pipeline behavior in response to varying the condemnation rate for a reparable of interest. If enough samples are taken, a regression model could be constructed to predict the costs associated with a given reparable for a given

weapon system as the weapon system ages. Since the B-1 is still a relatively new weapon system, it may be suitable for a study of this nature.

For this future research option, the independent variables would be condemnation rate of the reparable of interest and pipeline configuration (LL or current). The dependent variable would be estimated cost to operate the system (transportation cost + asset outlays). The experimental design could be 2 X N factorial, where the N is a large number of different levels for the condemnation rate factor. After the regression models were built for each pipeline configuration, the condemnation rate could be predicted for the reparable that would make it worthwhile to transition to a LL pipeline configuration.

Chapter Summary

This chapter discussed the conclusions drawn from the research. First, the findings were summarized. Next, they were interpreted from a management perspective. Finally, some recommendation for future research were presented.

Thesis Summary

This research demonstrated that there is a significant difference between the performance of the current reparable logistics pipeline and that proposed under Lean Logistics with respect to aircraft availability and transportation

cost. It further demonstrated that there are possibilities other than the pure treatments of the traditional or LL system that garner better aircraft availability and transportation cost performance. This research provided a baseline simulation model other researchers can use to test the two systems against one another, and provided some fundamental findings about the performance of the LL system as it would be used for B-1 aircraft.

Appendix A: Glossary

Base level - Those agencies designed specifically to support the base at which it is located.   In many cases the headquarters or depot-level functions are co-located with base-level functions.   Base-level supply will refer only to those functions performed in support of the assigned base. This is considered the retail level of asset management.

Concurrent Demand - Asset demand that occurs in conjunction with demand of other applicable bases over time.

Depot - That level that supports both the base and the intermediate supply points.   This is considered the wholesale level of asset management.

Intermediate Supply Point/Warehouse - The LL consolidation point of all assets repositioned from bases.   Located at the depot.

Non-concurrent Demand - Asset demand that occurs independent of the demand of other bases over time.

Reparables - Assets that are considered to be more economical to repair and re-manufacture than to dispose of and reprocure.

Retail - Used interchangeably with the term base level.

Stockage Levels - The predetermined quantity of a specific reparable asset to be stored at a given location, whether that be at a base, depot, or intermediate supply warehouse.

Wholesale - Used interchangeably with the term depot level.

104

Appendix B: SLAM II Model

```
GEN,HILLWALKER,TESTHLH,31/7/1994,30,N,N,Y/Y,N,Y/1,72;
LIMITS,30,20,15000;
INITIALIZE,,1095,Y;
INTLC,XX(2)=1,XX(3)=1,XX(4)=3,XX(5)=2,XX(6)=3;
INTLC,XX(31)=4,XX(32)=2,XX(33)=9,XX(34)=4,XX(35)=7;
INTLC,XX(40)=2,XX(41)=2,XX(42)=3,XX(43)=2,XX(44)=3;
INTLC,XX(50)=1,XX(51)=1,XX(52)=2,XX(53)=1,XX(54)=2;
INTLC,XX(60)=1,XX(61)=1,XX(62)=2,XX(63)=1,XX(64)=2;
INTLC,XX(1)=24,XX(7)=24,XX(8)=24,XX(9)=24,XX(10)=24;
INTLC,XX(45)=28,XX(46)=28,XX(47)=28,XX(48)=28,XX(49)=28;
INTLC,XX(55)=16,XX(56)=16,XX(57)=16,XX(58)=16,XX(59)=16;
INTLC,XX(65)=16,XX(66)=16,XX(67)=16,XX(68)=16,XX(69)=16;
TIMST,XX(105),EST ACFT AVAIL;
TIMST,XX(110),AV BS FILL RATE;
TIMST,XX(111),AV DS FILL RATE;
TIMST,XX(112), TRANS COST;
NETWORK;
        RESOURCE/1,BLINK1(0),2;
        RESOURCE/2,BLINK2(0),4;
        RESOURCE/3,BLINK3(0),6;
        RESOURCE/4,BLINK4(0),8;
        RESOURCE/5,BLINK5(0),10;
        RESOURCE/6,BLINK6(0),12;
        RESOURCE/7,BLINK7(0),14;
        RESOURCE/8,BLINK8(0),16;
        RESOURCE/9,BLINK9(0),18;
        RESOURCE/10,BLINK10(0),20;
        RESOURCE/11,BLINK11(0),22;
        RESOURCE/12,BLINK12(0),24;
        RESOURCE/13,BLINK13(0),26;
        RESOURCE/14,BLINK14(0),28;
        RESOURCE/15,BLINK15(0),30;
        RESOURCE/16,BLINK16(0),1;
        RESOURCE/17,BLINK17(0),3;
        RESOURCE/18,BLINK18(0),5;
        RESOURCE/19,BLINK19(0),7;
        RESOURCE/20,BLINK20(0),9;
        RESOURCE/21,BLINK21(0),11;
        RESOURCE/22,BLINK22(0),13;
        RESOURCE/23,BLINK23(0),15;
        RESOURCE/24,BLINK24(0),17;
        RESOURCE/25,BLINK25(0),19;
        RESOURCE/26,BLINK26(0),21;
        RESOURCE/27,BLINK27(0),23;
        RESOURCE/28,BLINK28(0),25;
        RESOURCE/29,BLINK29(0),27;
        RESOURCE/30,BLINK30(0),29;
;
;       COMPUTE DEPENDENT VARIABLES OF INTEREST
;
        CREATE,7,7,,,;
```

```
          ACTIVITY;
          ASSIGN,XX(101)=XX(1)*XX(7)*XX(8)*XX(9)*XX(10)/7962624;
          ASSIGN,XX(102)=XX(45)*XX(46)*XX(47)*XX(48)*XX(49)/17210368;
          ASSIGN,XX(103)=XX(55)*XX(56)*XX(57)*XX(58)*XX(59)/1048576;
          ASSIGN,XX(104)=XX(65)*XX(66)*XX(67)*XX(68)*XX(69)/1048576;
          ASSIGN,XX(105)=XX(101)/4+XX(102)/4+XX(103)/4+XX(104)/4;
          ASSIGN,XX(106)=XX(2)/5+XX(3)/5+XX(4)/15+XX(5)/10+XX(6)/15;
          ASSIGN,XX(107)=XX(40)/10+XX(41)/10+XX(42)/15+XX(43)/10+XX(44)/15;
          ASSIGN,XX(108)=XX(50)/5+XX(51)/5+XX(52)/10+XX(53)/5+XX(54)/10;
          ASSIGN,XX(109)=XX(60)/5+XX(61)/5+XX(62)/10+XX(63)/5+XX(64)/10;
          ASSIGN,XX(110)=XX(106)/4+ XX(107)/4+XX(108)/4+XX(109)/4;
          ASSIGN,XX(111)=XX(31)/20+XX(32)/10+XX(33)/45+XX(34)/20+XX(35)/35;
          ASSIGN,XX(112)=XX(21)+XX(22)+XX(23)+XX(24)+XX(25);
          ACTIVITY;
          TERMINATE;
;
;         HML AT ELLSWORTH, TREATMENT HLH
;
          CREATE,EXPON(33.33),,1,,1,
          ACTIVITY/1,RLOGN(1,0.3);
EHML      ASSIGN,ATRIB(10)=RLOGN(51,16),ATRIB(11)=1.0,ATRIB(12)=0.0;
          ASSIGN,ATRIB(6)=0.36,ATRIB(7)=0.64,ATRIB(8)=RLOGN(22,7);
          ASSIGN,ATRIB(9)=0.0,ATRIB(5)=RLOGN(5,1),ATRIB(4)=1,ATRIB(2)=1;
          ASSIGN,XX(1)=XX(1)-1,1;
          ACTIVITY;
          GOON,2;
          ACTIVITY/2;
          ACTIVITY/3,,,EHAA;
          GOON,1;
          ACTIVITY/4,,XX(2).LT.1;
          ACTIVITY/5,,XX(2).GE.1,EHAB;
          AWAIT(2),BLINK1,,1;
          ACTIVITY;
          ALTER,BLINK1,-1,1;
          ACTIVITY;
          FREE,BLINK1,1;
          ACTIVITY;
          ASSIGN,XX(2)=XX(2)-1,1;
          ACTIVITY/6,RLOGN(1,0.33);
          ASSIGN,XX(1)=XX(1)+1,1;
          ACTIVITY;
          TERMINATE;
EHAB      ASSIGN,XX(2)=XX(2)-1,1;
          .ACTIVITY/7,RLOGN(1,0.33);
          ASSIGN,XX(1)=XX(1)+1,1;
          ACTIVITY;
          TERMINATE;
EHAA      GOON,1;
          ACTIVITY/8;
          ACTIVITY/9,,ATRIB(9),EHAC;
          GOON,1;
          ACTIVITY/10,ATRIB(5),ATRIB(6);
          ACTIVITY/11,,ATRIB(7),EHAD;
          ASSIGN,XX(2)=XX(2)+1,1;
          ACTIVITY;
          TERMINATE;
EHAD      GOON,2;
          ACTIVITY;
```

```
          ACTIVITY/13,,,DS;
          ASSIGN,XX(21)=XX(21)+77.70,1;
          ACTIVITY/12,ATRIB(8),,DR;
EHAC      ASSIGN,XX(11)=XX(11)+1,2;
          ACTIVITY/14,,,DS;
          ACTIVITY/15;
          TERMINATE;
;
          CREATE,1,,1,1,1;
          ACTIVITY;
EHAE      GOON,1;
          ACTIVITY,0.05,XX(2).LT.1.OR.NNQ(2).EQ.0,EHAE;
          ACTIVITY,,XX(2).GE.1.AND.NNQ(2).GE.1;
          ALTER,BLINK1,1,1;
          ACTIVITY,.05,,EHAE;
;
;         SPLR AT ELLSWORTH,TREATMENT HLH
;
          CREATE,EXPON(20),,1,,1;
          ACTIVITY/16,RLOGN(1,0.3);
ESPL      ASSIGN,ATRIB(10)=RLOGN(21,6),ATRIB(11)=1.0,ATRIB(12)=0.0;
          ASSIGN,ATRIB(6)=0.68,ATRIB(7)=0.32,ATRIB(8)=RLOGN(22,7);
          ASSIGN,ATRIB(9)=0.0,ATRIB(5)=RLOGN(4,1),ATRIB(4)=2,ATRIB(2)=1;
          ASSIGN,XX(7)=XX(7)-1,1;
          ACTIVITY;
          GOON,2;
          ACTIVITY/17;
          ACTIVITY/18,,,ESAA;
          GOON,1;
          ACTIVITY/19,,XX(3).LT.1;
          ACTIVITY/20,,XX(3).GE.1,ESAB;
          AWAIT(4),BLINK2,,1;
          ACTIVITY;
          ALTER,BLINK2,-1,1;
          ACTIVITY;
          FREE,BLINK2,1;
          ACTIVITY;
          ASSIGN,XX(3)=XX(3)-1,1;
          ACTIVITY/21,RLOGN(1,0.33);
          ASSIGN,XX(7)=XX(7)+1,1;
          ACTIVITY;
          TERMINATE;
ESAB      ASSIGN,XX(3)=XX(3)-1,1;
          ACTIVITY/22,RLOGN(1,0.33);
          ASSIGN,XX(7)=XX(7)+1,1;
          ACTIVITY;
          TERMINATE;
ESAA      GOON,1;
          ACTIVITY/23;
          ACTIVITY/24,,ATRIB(9),ESAC;
          GOON,1;
          ACTIVITY/25,ATRIB(5),ATRIB(6);
          ACTIVITY/26,,ATRIB(7),ESAD;
          ASSIGN,XX(3)=XX(3)+1,1;
          ACTIVITY;
          TERMINATE;
ESAD      GOON,2;
          ACTIVITY;
```

```
        ACTIVITY/28,,,DS;
        ASSIGN,XX(22)=XX(22)+124.32,1;
        ACTIVITY/27,ATRIB(8),,DR;
ESAC    ASSIGN,XX(12)=XX(12)+1,2;
        ACTIVITY/29,,,DS;
        ACTIVITY/30;
        TERMINATE;
;
        CREATE,1,,1,1,1;
        ACTIVITY;
ESAE    GOON,1;
        ACTIVITY,0.05,XX(3).LT.1.OR.NNQ(4).EQ.0,ESAE;
        ACTIVITY,,XX(3).GE.1.AND.NNQ(4).GE.1;
        ALTER,BLINK2,1,1;
        ACTIVITY,0.05,,ESAE;
;
;       INERT AT ELLSWORTH, TREATMENT HLH
;
        CREATE,EXPON(10),,1,,1;
        ACTIVITY/31,RLOGN(1,0.3);
EINT    ASSIGN,ATRIB(10)=RLOGN(53,17),ATRIB(11)=1.0,ATRIB(12)=0.0;
        ASSIGN,ATRIB(6)=0.53,ATRIB(7)=0.47,ATRIB(8)=RLOGN(22,7);
        ASSIGN,ATRIB(9)=0.0,ATRIB(5)=RLOGN(5,1),ATRIB(4)=3,ATRIB(2)=1;
        ASSIGN,XX(8)=XX(8)-1,1;
        ACTIVITY;
        GOON,2;
        ACTIVITY/32;
        ACTIVITY/33,,,EIAA;
        GOON,1;
        ACTIVITY/34,,XX(4).LT.1;
        ACTIVITY/35,,XX(4).GE.1,EIAB;
        AWAIT(6),BLINK3,,1;
        ACTIVITY;
        ALTER,BLINK3,-1,1;
        ACTIVITY;
        FREE,BLINK3,1;
        ACTIVITY;
        ASSIGN,XX(4)=XX(4)-1,1;
        ACTIVITY/36,RLOGN(1,0.33);
        ASSIGN,XX(8)=XX(8)+1,1;
        ACTIVITY;
        TERMINATE;
EIAB    ASSIGN,XX(4)=XX(4)-1,1;
        ACTIVITY/37,RLOGN(1,0.33);
        ASSIGN,XX(8)=XX(8)+1,1;
        ACTIVITY;
        TERMINATE;
EIAA    GOON,1;
        ACTIVITY/38;
        ACTIVITY/39,,ATRIB(9),EIAC;
        GOON,1;
        ACTIVITY/40,ATRIB(5),ATRIB(6);
        ACTIVITY/41,,ATRIB(7),EIAD;
        ASSIGN,XX(4)=XX(4)+1,1;
        ACTIVITY;
        TERMINATE;
EIAD    GOON,2;
        ACTIVITY/42;
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        ACTIVITY/44,,,DS;
        ASSIGN,XX(23)=XX(23)+151.52,1;
        ACTIVITY/43,ATRIB(8),,DR;
EIAC    ASSIGN,XX(13)=XX(13)+1,2;
        ACTIVITY/45,,,DS;
        ACTIVITY;
        TERMINATE;
;
        CREATE,1,,1,1,1;
        ACTIVITY;
EIAE    GOON,1;
        ACTIVITY,0.05,XX(4).LT.1.OR.NNQ(6).EQ.0,EIAE;
        ACTIVITY,,XX(4).GE.1.AND.NNQ(6).GE.1;
        ALTER,BLINK3,1,1;
        ACTIVITY,0.05,,EIAE;
;
;       FLAP AT ELLWORTH, TREATMENT HLH
;
        CREATE,EXPON(16.67),,1,,1;
        ACTIVITY/46,RLOGN(1,0.3);
EFLP    ASSIGN,ATRIB(10)=RLOGN(23,7),ATRIB(11)=1.0,ATRIB(12)=0.0;
        ASSIGN,ATRIB(6)=0.55,ATRIB(7)=0.45,ATRIB(8)=RLOGN(22,7);
        ASSIGN,ATRIB(9)=0.0,ATRIB(5)=RLOGN(3,.9),ATRIB(4)=4,ATRIB(2)=1;
        ASSIGN,XX(9)=XX(9)-1,1;
        ACTIVITY;
        GOON,2;
        ACTIVITY/47;
        ACTIVITY/48,,,EFAA;
        GOON,1;
        ACTIVITY/49,,XX(5).LT.1;
        ACTIVITY/50,,XX(5).GE.1,EFAB;
        AWAIT(8),BLINK4,,1;
        ACTIVITY;
        ALTER,BLINK4,-1,1;
        ACTIVITY;
        FREE,BLINK4,1;
        ACTIVITY;
        ASSIGN,XX(5)=XX(5)-1,1;
        ACTIVITY/51,RLOGN(1,0.33);
        ASSIGN,XX(9)=XX(9)+1,1;
        ACTIVITY;
        TERMINATE;
EFAB    ASSIGN,XX(5)=XX(5)-1,1;
        ACTIVITY/52,RLOGN(1,0.33);
        ASSIGN,XX(9)=XX(9)+1,1;
        ACTIVITY;
        TERMINATE;
EFAA    GOON,1;
        ACTIVITY/53;
        ACTIVITY/54,,ATRIB(9),EFAC;
        GOON,1;
        ACTIVITY/55,ATRIB(5),ATRIB(6);
        ACTIVITY/56,,ATRIB(7),EFAD;
        ASSIGN,XX(5)=XX(5)+1,1;
        ACTIVITY;
        TERMINATE;
EFAD    GOON,2;
        ACTIVITY/57;
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        ACTIVITY/59,,,DS;
        ASSIGN,XX(24)=XX(24)+93.63,1;
        ACTIVITY/58,ATRIB(8),,DR;
EFAC    ASSIGN,XX(14)=XX(14)+1,2;
        ACTIVITY/60,,,DS;
        ACTIVITY;
        TERMINATE;
;
        CREATE,1,,1,1,1;
        ACTIVITY;
EFAE    GOON,1;
        ACTIVITY,0.05,XX(5).LT.1.OR.NNQ(8).EQ.0,EFAE;
        ACTIVITY,,XX(5).GE.1.AND.NNQ(8).GE.1;
        ALTER,BLINK4,1,1;
        ACTIVITY,0.05,,EFAE;
;
;       CONV AT ELLSWORTH, TREATMENT HLH
;
        CREATE,EXPON(7.7,,,1,,1;
        ACTIVITY/61,RLOGN(1,0.33);
ECON    ASSIGN,ATRIB(10)=RLOGN(46,15),ATRIB(11)=1.0,ATRIB(12)=0.0;
        ASSIGN,ATRIB(6)=0.73,ATRIB(7)=0.27,ATRIB(8)=RLOGN(22,7);
        ASSIGN,ATRIB(9)=0.0,ATRIB(5)=RLOGN(6,2),ATRIB(4)=5,ATRIB(2)=1;
        ASSIGN,XX(10)=XX(10)-1,1;
        ACTIVITY;
        GOON,2;
        ACTIVITY/62;
        ACTIVITY/63,,,ECAA;
        GOON,1;
        ACTIVITY/64,,XX(6).LT.1;
        ACTIVITY/65,,XX(6).GE.1,ECAB;
        AWAIT(10),BLINK5,,1;
        ACTIVITY;
        ALTER,BLINK5,-1,1;
        ACTIVITY;
        FREE,BLINK5,1;
        ACTIVITY;
        ASSIGN,XX(6)=XX(6)-1,1;
        ACTIVITY/66,RLOGN(1,0.33);
        ASSIGN,XX(10)=XX(10)+1,1;
        ACTIVITY;
        TERMINATE;
ECAB    ASSIGN,XX(6)=XX(6)-1,1;
        ACTIVITY/67,RLOGN(1,0.33);
        ASSIGN,XX(10)=XX(10)+1,1;
        ACTIVITY;
        TERMINATE;
ECAA    GOON,1;
        ACTIVITY/68;
        ACTIVITY/69,,ATRIB(9),ECAC;
        GOON,1;
        ACTIVITY/70,ATRIB(5),ATRIB(6);
        ACTIVITY/71,,ATRIB(7),ECAD;
        ASSIGN,XX(6)=XX(6)+1,1;
        ACTIVITY/72;
        TERMINATE;
ECAD    GOON,2;
        ACTIVITY;
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        ACTIVITY/74,,,DS;
        ASSIGN,XX(25)=XX(25)+128.21,1;
        ACTIVITY/73,ATRIB(8),,DR;
ECAC    ASSIGN,XX(15)=XX(15)+1,2;
        ACTIVITY/75,,,DS;
        ACTIVITY;
        TERMINATE;
;
        CREATE,1,,1,1,1;
        ACTIVITY;
ECAE    GOON,1;
        ACTIVITY,0.05,XX(6).LT.1.OR.NNQ(10).EQ.0,ECAE;
        ACTIVITY,,XX(6).GE.1.AND.NNQ(10).GE.1;
        ALTER,BLINK5,1,1;
        ACTIVITY,0.05,,ECAE;
;
;       DEPOT/ISP SUPPLY ACTIVITY
;
DS      GOON,1;
        ACTIVITY/76,,ATRIB(4).EQ.1;
        ACTIVITY/77,,ATRIB(4).EQ.2,ZAFU;
        ACTIVITY/78,,ATRIB(4).EQ.3,ZAFY;
        ACTIVITY/79,,ATRIB(4).EQ.4,ZAGC;
        ACTIVITY/80,,ATRIB(4).EQ.5,ZAGG;
        AWAIT(12),BLINK6,,1;
        ACTIVITY;
        ALTER,BLINK6,-1,1;
        ACTIVITY;
        FREE,BLINK6,1;
        ACTIVITY;
        ASSIGN,XX(31)=XX(31)-1,1;
        ACTIVITY,,ATRIB(2).EQ.1;
        ACTIVITY,,ATRIB(2).EQ.2,ZAFO;
        ACTIVITY,,ATRIB(2).EQ.3,ZAFP;
        ACTIVITY,,ATRIB(2).EQ.4,ZAFQ;
        GOON,1;
        ACTIVITY;
        ASSIGN,XX(21)=XX(21)+77.70,1;
        ACTIVITY/81,ATRIB(8);
        ASSIGN,XX(2)=XX(2)+1,1;
        ACTIVITY;
        TERMINATE;
ZAFO    GOON,1;
        ACTIVITY;
        ASSIGN,XX(21)=XX(21)+12.95,1;
        ACTIVITY,ATRIB(8);
        ASSIGN,XX(40)=XX(40)+1,1;
        TERMINATE;
ZAFP    GOON,1;
        ACTIVITY;
        ASSIGN,XX(21)=XX(21)+77.70,1;
        ACTIVITY,ATRIB(8);
        ASSIGN,XX(50)=XX(50)+1,1;
        TERMINATE;
ZAFQ    GOON,1;
        ACTIVITY;
        ASSIGN,XX(21)=XX(21)+18.13,1;
        ACTIVITY,ATRIB(8);
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111

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        ASSIGN,XX(60)=XX(60)+1,1;
        TERMINATE;
ZAFU    AWAIT(14),BLINK7,,1;
        ACTIVITY;
        ALTER,BLINK7,-1,1;
        ACTIVITY;
        FREE,BLINK7,1;
        ACTIVITY;
        ASSIGN,XX(32)=XX(32)-1,1;
        ACTIVITY,,ATRIB(2).EQ.1;
        ACTIVITY,,ATRIB(2).EQ.2,ZAFR;
        ACTIVITY,,ATRIB(2).EQ.3,ZAFS;
        ACTIVITY,,ATRIB(2).EQ.4,ZAFT;
        GOON,1;
        ACTIVITY;
        ASSIGN,XX(22)=XX(22)+124.32,1;
        ACTIVITY/82,ATRIB(8);
        ASSIGN,XX(3)=XX(3)+1,1;
        ACTIVITY;
        TERMINATE;
ZAFR    GOON,1;
        ACTIVITY;
        ASSIGN,XX(22)=XX(22)+20.72,1;
        ACTIVITY,ATRIB(8);
        ASSIGN,XX(41)=XX(41)+1,1;
        TERMINATE;
ZAFS    GOON,1;
        ACTIVITY;
        ASSIGN,XX(22)=XX(22)+124.32,1;
        ACTIVITY,ATRIB(8);
        ASSIGN,XX(51)=XX(51)+1,1;
        TERMINATE;
ZAFT    GOON,1;
        ACTIVITY;
        ASSIGN,XX(22)=XX(22)+29.01,1;
        ACTIVITY,ATRIB(8);
        ASSIGN,XX(61)=XX(61)+1,1;
        TERMINATE;
ZAFY    AWAIT(16),BLINK8,,1;
        ACTIVITY;
        ALTER,BLINK8,-1,1;
        ACTIVITY;
        FREE,BLINK8,1;
        ACTIVITY;
        ASSIGN,XX(33)=XX(33)-1,1;
        ACTIVITY,,ATRIB(2).EQ.1;
        ACTIVITY,,ATRIB(2).EQ.2,ZAFV;
        ACTIVITY,,ATRIB(2).EQ.3,ZAFW;
        ACTIVITY,,ATRIB(2).EQ.4,ZAFX;
        GOON,1;
        ACTIVITY;
        ASSIGN,XX(23)=XX(23)+151.52,1;
        ACTIVITY/83,ATRIB(8);
        ASSIGN,XX(4)=XX(4)+1,1;
        ACTIVITY;
        TERMINATE;
ZAFV    GOON,1;
        ACTIVITY;
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              ASSIGN,XX(23)=XX(23)+25.25,1;
              ACTIVITY,ATRIB(8);
              ASSIGN,XX(42)=XX(42)+1,1;
              TERMINATE;
       ZAFW   GOON,1;
              ACTIVITY;
              ASSIGN,XX(23)=XX(23)+151.52,1;
              ACTIVITY,ATRIB(8);
              ASSIGN,XX(52)=XX(52)+1,1;
              TERMINATE;
       ZAFX   GOON,1;
              ACTIVITY;
              ASSIGN,XX(23)=XX(23)+35.35,1;
              ACTIVITY,ATRIB(8);
              ASSIGN,XX(62)=XX(62)+1,1;
              TERMINATE;
       ZAGC   AWAIT(18),BLINK9,,1;
              ACTIVITY;
              ALTER,BLINK9,-1,1;
              ACTIVITY;
              FREE,BLINK9,1;
              ACTIVITY;
              ASSIGN,XX(34)=XX(34)-1,1;
              ACTIVITY,,ATRIB(2).EQ.1;
              ACTIVITY,,ATRIB(2).EQ.2,ZAFZ;
              ACTIVITY,,ATRIB(2).EQ.3,ZAGA;
              ACTIVITY,,ATRIB(2).EQ.4,ZAGB;
              GOON,1;
              ACTIVITY;
              ASSIGN,XX(24)=XX(24)+93.63,1;
              ACTIVITY/84,ATRIB(8);
              ASSIGN,XX(5)=XX(5)+1,1;
              ACTIVITY;
              TERMINATE;
       ZAFZ   GOON,1;
              ACTIVITY;
              ASSIGN,XX(24)=XX(24)+15.60,1;
              ACTIVITY,ATRIB(8);
              ASSIGN,XX(43)=XX(43)+1,1;
              TERMINATE;
       ZAGA   GOON,1;
              ACTIVITY;
              ASSIGN,XX(24)=XX(24)+93.63,1;
              ACTIVITY,ATRIB(8);
              ASSIGN,XX(53)=XX(53)+1,1;
              TERMINATE;
       ZAGB   GOON,1;
              ACTIVITY;
              ASSIGN,XX(24)=XX(24)+21.85,1;
              ACTIVITY,ATRIB(8);
              ASSIGN,XX(63)=XX(63)+1,1;
              TERMINATE;
       ZAGG   AWAIT(20),BLINK10,,1;
              ACTIVITY;
              ALTER,BLINK10,-1,1;
              ACTIVITY;
              FREE,BLINK10,1,
              ACTIVITY;
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113

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              ASSIGN,XX(35)=XX(35)-1,1;
              ACTIVITY,,ATRIB(2).EQ.1;
              ACTIVITY,,ATRIB(2).EQ.2,ZAGD;
              ACTIVITY,,ATRIB(2).EQ.3,ZAGE;
              ACTIVITY,,ATRIB(2).EQ.4,ZAGF;
              GOON,1;
              ACTIVITY;
              ASSIGN,XX(25)=XX(25)+128.21,1;
              ACTIVITY/85,ATRIB(8);
              ASSIGN,XX(6)=XX(6)+1,1;
              ACTIVITY;
              TERMINATE;
       ZAGD   GOON,1;
              ACTIVITY;
              ASSIGN,XX(25)=XX(25)+21.37,1;
              ACTIVITY,ATRIB(8);
              ASSIGN,XX(44)=XX(44)+1,1;
              TERMINATE;
       ZAGE   GOON,1;
              ACTIVITY;
              ASSIGN,XX(25)=XX(25)+128.21,1;
              ACTIVITY,ATRIB(8);
              ASSIGN,XX(54)=XX(54)+1,1;
              TERMINATE;
       ZAGF   GOON,1;
              ACTIVITY;
              ASSIGN,XX(25)=XX(25)+29.91,1;
              ACTIVITY,ATRIB(8);
              ASSIGN,XX(64)=XX(64)+1,1;
              TERMINATE;
       ;
              CREATE,1,,1,1,1;
              ACTIVITY;
       ZAFB   GOON,1;
              ACTIVITY,0.05,XX(31).LT.1.OR.NNQ(12).EQ.0,ZAFB;
              ACTIVITY,,XX(31).GE.1.AND.NNQ(12).GE.1;
              ALTER,BLINK6,1,1;
              ACTIVITY,0.05,,ZAFB;
       ;
              CREATE,1,,1,1,1;
              ACTIVITY;
       ZAFC   GOON,1;
              ACTIVITY,0.05,XX(32).LT.1.OR.NNQ(14).EQ.0,ZAFC;
              ACTIVITY,,XX(32).GE.1.AND.NNQ(14).GE.1;
              ALTER,BLINK7,+1,1;
              ACTIVITY,0.05,,ZAFC;
       ;
              CREATE,1,,1,1,1;
              ACTIVITY;
       ZAFD   GOON,1;
              ACTIVITY,0.05,XX(33).LT.1.OR.NNQ(16).EQ.0,ZAFD;
              ACTIVITY,,XX(33).GE.1.AND.NNQ(16).GE.1;
              ALTER,BLINK8,1,1;
              ACTIVITY,0.05,,ZAFD;
       ;
              CREATE,1,,1,1,1;
              ACTIVITY;
       ZAFE   GOON,1;
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                ACTIVITY,0.05,XX(34).LT.1.OR.NNQ(18).EQ.0,ZAFE;
                ACTIVITY,,XX(34).GE.1.AND.NNQ(18).GE.1;
                ALTER,BLINK9,1,1;
                ACTIVITY,0.05,,ZAFE;
        ;
                CREATE,1,,1,1,1;
                ACTIVITY;
        ZAFJ    GOON,1;
                ACTIVITY,0.05,XX(35).LT.1.OR.NNQ(20).EQ.0,ZAFJ;
                ACTIVITY,,XX(35).GE.1.AND.NNQ(20).GE.1;
                ALTER,BLINK10,1,1;
                ACTIVITY,0.05,,ZAFJ;
        ;
        ;       DEPOT REPAIR ACTIVITY
        ;
        DR      GOON,1;
                ACTIVITY/86,,ATRIB(4).EQ.1;
                ACTIVITY/87,,ATRIB(4).EQ.2,ZAHB;
                ACTIVITY/88,,ATRIB(4).EQ.3,ZAHD;
                ACTIVITY/89,,ATRIB(4).EQ.4,ZAHF;
                ACTIVITY/90,,ATRIB(4).EQ.5,ZAHH;
                AWAIT(22),BLINK11,,1;
                ACTIVITY;
                ALTER,BLINK11,-1,1;
                ACTIVITY;
                FREE,BLINK11,1;
                ACTIVITY/91,ATRIB(10),ATRIB(11);
                ACTIVITY/92,,ATRIB(12),ZAGZ;
                ASSIGN,XX(31)=XX(31)+1,1;
                ACTIVITY;
                TERMINATE;
        ZAGZ    ASSIGN,XX(11)=XX(11)+1,1;
                ACTIVITY;
                TERMINATE;
        ZAHB    AWAIT(24),BLINK12,,1;
                ACTIVITY;
                ALTER,BLINK12,-1,1;
                ACTIVITY;
                FREE,BLINK12,1;
                ACTIVITY/93,ATRIB(10),ATRIB(11);
                ACTIVITY/94,,ATRIB(12),ZAHA;
                ASSIGN,XX(32)=XX(32)+1,1;
                ACTIVITY;
                TERMINATE;
        ZAHA    ASSIGN,XX(12)=XX(12)+1,1;
                ACTIVITY;
                TERMINATE;
        ZAHD    AWAIT(26),BLINK13,,1;
                ACTIVITY;
                ALTER,BLINK13,-1,1;
                ACTIVITY;
                FREE,BLINK13,1;
                ACTIVITY/95,ATRIB(10),ATRIB(11);
                ACTIVITY/96,,0,ZAHC;
                ASSIGN,XX(33)=XX(33)+1,1;
                ACTIVITY;
                TERMINATE;
        ZAHC    ASSIGN,XX(13)=XX(13)+1,1;
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        ACTIVITY;
        TERMINATE;
ZAHF    AWAIT(28),BLINK14,,1;
        ACTIVITY;
        ALTER,BLINK14,-1,1;
        ACTIVITY;
        FREE,BLINK14,1;
        ACTIVITY/97,ATRIB(10),ATRIB(11);
        ACTIVITY/98,,ATRIB(12),ZAHE;
        ASSIGN,XX(34)=XX(34)+1,1;
        ACTIVITY;
        TERMINATE;
ZAHE    ASSIGN,XX(14)=XX(14)+1,1;
        ACTIVITY;
        TERMINATE;
ZAHH    AWAIT(30),BLINK15,,1;
        ACTIVITY;
        ALTER,BLINK15,-1,1;
        ACTIVITY;
        FREE,BLINK15,1;
        ACTIVITY/99,ATRIB(10),ATRIB(11);
        ACTIVITY/100,,ATRIB(12),ZAHG;
        ASSIGN,XX(35)=XX(35)+1,1;
        ACTIVITY;
        TERMINATE;
ZAHG    ASSIGN,XX(15)=XX(15)+1,1;
        ACTIVITY;
        TERMINATE;
;
        CREATE,1,,1,1,1;
        ACTIVITY;
ZAGP    GOON,1;
        ACTIVITY,0.05,XX(31).GE.100.OR.NNQ(22).EQ.0,ZAGP;
        ACTIVITY,,XX(31).LT.100.AND.NNQ(22).GE.1;
        ALTER,BLINK11,1,1;
        ACTIVITY,0.05,,ZAGP;
;
        CREATE,365,,1,,1;
        ACTIVITY;
        ASSIGN,ATRIB(13)=XX(11),XX(11)=0,1;
        ACTIVITY,RNORM(730,73);
        ASSIGN,XX(31)=XX(31)+ATRIB(13),1;
        ACTIVITY;
        TERMINATE;
;
        CREATE,1,,1,1,1;
        ACTIVITY;
ZAGQ    GOON,1;
        ACTIVITY,0.05,XX(32).GE.100.OR.NNQ(24).EQ.0,ZAGQ;
        ACTIVITY,,XX(32).LT.100.AND.NNQ(24).GE.1;
        ALTER,BLINK12,1,1;
        ACTIVITY,0.05,,ZAGQ;
;
        CREATE,365,,1,,1;
        ACTIVITY;
        ASSIGN,ATRIB(13)=XX(12),XX(12)=0,1;
        ACTIVITY,RNORM(730,73);
        ASSIGN,XX(32)=XX(32)+ATRIB(13),1;
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            ACTIVITY;
            TERMINATE;
      ;
            CREATE,1,,1,1,1;
            ACTIVITY;
ZAGS  GOON,1;
            ACTIVITY,0.05,XX(33).GE.100.OR.NNQ(26).EQ.0,ZAGS;
            ACTIVITY,,XX(33).LT.100.AND.NNQ(26).GE.1;
            ALTER,BLINK13,1,1;
            ACTIVITY,0.05,,ZAGS;
      ;
            CREATE,365,,1,,1;
            ACTIVITY;
            ASSIGN,ATRIB(13)=XX(13),XX(13)=0,1;
            ACTIVITY,RNORM(730,73);
            ASSIGN,XX(33)=XX(33)+ATRIB(13),1;
            ACTIVITY;
            TERMINATE;
      ;
            CREATE,1,,1,1,1;
            ACTIVITY;
ZAGU  GOON,1;
            ACTIVITY,0.05,XX(34).GE.100.OR.NNQ(28).EQ.0,ZAGU;
            ACTIVITY,,XX(34).LT.100.AND.NNQ(28).GE.1;
            ALTER,BLINK14,1,1;
            ACTIVITY,0.05,,ZAGU;
      ;
            CREATE,365,,1,,1;
            ACTIVITY;
            ASSIGN,ATRIB(13)=XX(14),XX(14)=0,1;
            ACTIVITY,RNORM(730,73);
            ASSIGN,XX(34)=XX(34)+ATRIB(13),1;
            ACTIVITY;
            TERMINATE;
      ;
            CREATE,1,,1,1,1;
            ACTIVITY;
ZAGX  GOON,1;
            ACTIVITY,0.05,XX(35).GE.100.OR.NNQ(30).EQ.0,ZAGX;
            ACTIVITY,,XX(35).LT.100.AND.NNQ(30).GE.1;
            ALTER,BLINK15,1,1;
            ACTIVITY,0.05,,ZAGX;
      ;
            CREATE,365,,1,,1;
            ACTIVITY;
            ASSIGN,ATRIB(13)=XX(15),XX(15)=0,1;
            ACTIVITY,RNORM(730,73);
            ASSIGN,XX(35)=XX(35)+ATRIB(13),1;
            ACTIVITY;
            TERMINATE;
      ;
      ;     HML AT DYESS, TREATMENT HLH
      ;
            CREATE,EXPON(50),1,1,,1;
            ACTIVITY,RLOGN(1,.3);
DHML  ASSIGN,XX(45)=XX(45)-1,ATRIB(2)=2,ATRIB(4)=1,ATRIB(5)=RLOGN(5,1);
            ASSIGN,ATRIB(6)=.36,ATRIB(7)=0.64,ATRIB(8)=RLOGN(22,7);
            ASSIGN,ATRIB(9)=0.0,ATRIB(10)=RLOGN(51,16),ATRIB(11)=1.0;
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117

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        ASSIGN,ATRIB(12)=0.0,1;
        ACTIVITY;
        GOON,2;
        ACTIVITY;
        ACTIVITY,,,DHAA;
        GOON,1;
        ACTIVITY,,XX(40).LT.1;
        ACTIVITY,,XX(40).GE.1,DHAB;
        AWAIT(1),BLINK16,,1;
        ACTIVITY;
        ALTER,BLINK16,-1,1;
        ACTIVITY;
        FREE,BLINK16,1;
        ACTIVITY;
        ASSIGN,XX(40)=XX(40)-1,1;
        ACTIVITY,RLOGN(1,.3);
        ASSIGN,XX(45)=XX(45)+1,1;
        ACTIVITY;
        TERMINATE;
DHAB    ASSIGN,XX(40)=XX(40)-1,1;
        ACTIVITY,RLOGN(1,.3);
        ASSIGN,XX(45)=XX(45)+1,1;
        ACTIVITY;
        TERMINATE;
DHAA    GOON,1;
        ACTIVITY;
        ACTIVITY,,ATRIB(9),DHAC;
        GOON,1;
        ACTIVITY,ATRIB(5),ATRIB(6);
        ACTIVITY,,ATRIB(7),DHAD;
        ASSIGN,XX(40)=XX(40)+1,1;
        ACTIVITY;
        TERMINATE;
DHAD    GOON,2;
        ACTIVITY;
        ACTIVITY,,,DS;
        ASSIGN,XX(21)=XX(21)+12.95;
        ACTIVITY,ATRIB(8),,DR;
DHAC    ASSIGN,XX(11)=XX(11)+1,1;
        ACTIVITY,,,DS;
        ACTIVITY;
        TERMINATE;
;
        CREATE,1,,1,1,1;
        ACTIVITY;
DHAE    GOON,1;
        ACTIVITY,0.05,XX(40).LT.1.OR.NNQ(1).EQ.0,DHAE;
        ACTIVITY,,XX(40).GE.1.AND.NNQ(1).GE.1;
        ALTER,BLINK16,1,1;
        ACTIVITY,.05,,DHAE;
;
;       SPLR AT DYESS,TREATMENT HLH
;
        CREATE,EXPON(33.33),1,1,,1;
        ACTIVITY,RLOGN(1,.3);
DSPL    ASSIGN,XX(46)=XX(46)-1,ATRIB(2)=2,ATRIB(4)=2,ATRIB(5)=RLOGN(5,1);
        ASSIGN,ATRIB(6)=.36,ATRIB(7)=0.64,ATRIB(8)=RLOGN(22,7);
        ASSIGN,ATRIB(9)=0.0,ATRIB(10)=RLOGN(21,6),ATRIB(11)=1.0;
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118

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        ASSIGN,ATRIB(12)=0.0,1;
        ACTIVITY;
        GOON,2;
        ACTIVITY;
        ACTIVITY,,,DSAA;
        GOON,1;
        ACTIVITY,,XX(41).LT.1;
        ACTIVITY,,XX(41).GE.1,DSAB;
        AWAIT(3),BLINK17,,1;
        ACTIVITY;
        ALTER,BLINK17,-1,1;
        ACTIVITY;
        FREE,BLINK17,1;
        ACTIVITY;
        ASSIGN,XX(41)=XX(41)-1,1;
        ACTIVITY,RLOGN(1,.3);
        ASSIGN,XX(46)=XX(46)+1,1;
        ACTIVITY;
        TERMINATE;
DSAB    ASSIGN,XX(41)=XX(41)-1,1;
        ACTIVITY,RLOGN(1,.3);
        ASSIGN,XX(46)=XX(46)+1,1;
        ACTIVITY;
        TERMINATE;
DSAA    GOON,1;
        ACTIVITY;
        ACTIVITY,,ATRIB(9),DSAC;
        GOON,1;
        ACTIVITY,ATRIB(5),ATRIB(6);
        ACTIVITY,,ATRIB(7),DSAD;
        ASSIGN,XX(41)=XX(41)+1,1;
        ACTIVITY;
        TERMINATE;
DSAD    GOON,2;
        ACTIVITY;
        ACTIVITY,,,DS;
        ASSIGN,XX(22)=XX(22)+20.72;
        ACTIVITY,ATRIB(8),,DR;
DSAC    ASSIGN,XX(12)=XX(12)+1,1;
        ACTIVITY,,,DS;
        ACTIVITY;
        TERMINATE;
;
        CREATE,1,,1,1,1;
        ACTIVITY;
DSAE    GOON,1;
        ACTIVITY,0.05,XX(41).LT.1.OR.NNQ(3).EQ.0,DSAE;
        ACTIVITY,,XX(41).GE.1.AND.NNQ(3).GE.1;
        ALTER,BLINK17,1,1;
        ACTIVITY,0.05,,DSAE;
;
;       INERT AT DYESS, TREATMENT HLH
;
        CREATE,EXPON(14.29),1,1,,1;
        ACTIVITY,RLOGN(1,.3);
DINE    ASSIGN,XX(47)=XX(47)-1,ATRIB(2)=2,ATRIB(4)=3,ATRIB(5)=RLOGN(5,1);
        ASSIGN,ATRIB(6)=.36,ATRIB(7)=0.64,ATRIB(8)=RLOGN(22,7);
        ASSIGN,ATRIB(9)=0.0,ATRIB(10)=RLOGN(53,17),ATRIB(11)=1.0;
```

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        ASSIGN,ATRIB(12)=0.0,1;
        ACTIVITY;
        GOON,2;
        ACTIVITY;
        ACTIVITY,,,DIAA;
        GOON,1;
        ACTIVITY,,XX(42).LT.1;
        ACTIVITY,,XX(42).GE.1,DIAB;
        AWAIT(5),BLINK18,,1;
        ACTIVITY;
        ALTER,BLINK18,-1,1;
        ACTIVITY;
        FREE,BLINK18,1;
        ACTIVITY;
        ASSIGN,XX(42)=XX(42)-1,1;
        ACTIVITY,RLOGN(1,.3);
        ASSIGN,XX(47)=XX(47)+1,1;
        ACTIVITY;
        TERMINATE;
DIAB    ASSIGN,XX(42)=XX(42)-1,1;
        ACTIVITY,RLOGN(1,.3);
        ASSIGN,XX(47)=XX(47)+1,1;
        ACTIVITY;
        TERMINATE;
DIAA    GOON,1;
        ACTIVITY;
        ACTIVITY,,ATRIB(9),DIAC;
        GOON,1;
        ACTIVITY,ATRIB(5),ATRIB(6);
        ACTIVITY,,ATRIB(7),DIAD;
        ASSIGN,XX(42)=XX(42)+1,1;
        ACTIVITY;
        TERMINATE;
DIAD    GOON,2;
        ACTIVITY;
        ACTIVITY,,,DS;
        ASSIGN,XX(23)=XX(23)+25.25;
        ACTIVITY,ATRIB(8),,DR;
DIAC    ASSIGN,XX(13)=XX(13)+1,1;
        ACTIVITY,,,DS;
        ACTIVITY;
        TERMINATE;
;
        CREATE,1,,1,1,1;
        ACTIVITY;
DIAE    GOON,1;
        ACTIVITY,0.05,XX(42).LT.1.OR.NNQ(5).EQ.0,DIAE;
        ACTIVITY,,XX(42).GE.1.AND.NNQ(5).GE.1;
        ALTER,BLINK18,1,1;
        ACTIVITY,0.05,,DIAE;
;
;       FLAP AT DYESS, TREATMENT IILII
;
        CREATE,EXPON(25),1,1,,1;
        ACTIVITY,RLOGN(1,.3);
DFLA    ASSIGN,XX(48)=XX(48)-1,ATRIB(2)=2,ATRIB(4)=4,ATRIB(5)=RLOGN(5,1);
        ASSIGN,ATRIB(6)=.36,ATRIB(7)=0.64,ATRIB(8)=RLOGN(22,7);
        ASSIGN,ATRIB(9)=0.0,ATRIB(10)=RLOGN(23,7),ATRIB(11)=1.0;
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120

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          ASSIGN,ATRIB(12)=0.0,1;
          ACTIVITY;
          GOON,2;
          ACTIVITY;
          ACTIVITY,,DFAA;
          GOON,1;
          ACTIVITY,,XX(43).LT.1;
          ACTIVITY,,XX(43).GE.1,DFAB;
          AWAIT(7),BLINK19,,1;
          ACTIVITY;
          ALTER,BLINK19,-1,1;
          ACTIVITY;
          FREE,BLINK19,1;
          ACTIVITY;
          ASSIGN,XX(43)=XX(43)-1,1;
          ACTIVITY,RLOGN(1,.3);
          ASSIGN,XX(48)=XX(48)+1,1;
          ACTIVITY;
          TERMINATE;
DFAB      ASSIGN,XX(43)=XX(43)-1,1;
          ACTIVITY,RLOGN(1,.3);
          ASSIGN,XX(48)=XX(48)+1,1;
          ACTIVITY;
          TERMINATE;
DFAA      GOON,1;
          ACTIVITY;
          ACTIVITY,,ATRIB(9),DFAC;
          GOON,1;
          ACTIVITY,ATRIB(5),ATRIB(6);
          ACTIVITY,,ATRIB(7),DFAD;
          ASSIGN,XX(43)=XX(43)+1,1;
          ACTIVITY;
          TERMINATE;
DFAD      GOON,2;
          ACTIVITY;
          ACTIVITY,,,DS;
          ASSIGN,XX(24)=XX(24)+15.60;
          ACTIVITY,ATRIB(8),,DR;
DFAC      ASSIGN,XX(14)=XX(14)+1,1;
          ACTIVITY,,,DS;
          ACTIVITY;
          TERMINATE;
;
          CREATE,1,,1,1,1;
          ACTIVITY;
DFAE      GOON,1;
          ACTIVITY,0.05,XX(43).LT.1.OR.NNQ(7).EQ.0,DFAE;
          ACTIVITY,,XX(43).GE.1.AND.NNQ(7).GE.1;
          ALTER,BLINK19,1,1;
          ACTIVITY,0.05,,DFAE;
;
;         CONV AT DYESS, TREATMENT HLH
;
          CREATE,EXPON(10),,1,,1;
          ACTIVITY,RLOGN(1,.3);
DCON      ASSIGN,XX(49)=XX(49)-1,ATRIB(2)=2,ATRIB(4)=5,ATRIB(5)=RLOGN(5,1);
          ASSIGN,ATRIB(6)=.36,ATRIB(7)=0.64,ATRIB(8)=RLOGN(22,7);
          ASSIGN,ATRIB(9)=0.0,ATRIB(10)=RLOGN(46,15),ATRIB(11)=1.0;
```

```
        ASSIGN,ATRIB(12)=0.0,1;
        ACTIVITY;
        GOON,2;
        ACTIVITY;
        ACTIVITY,,,DCAA;
        GOON,1;
        ACTIVITY,,XX(44).LT.1;
        ACTIVITY,,XX(44).GE.1,DCAB;
        AWAIT(9),BLINK20,,1;
        ACTIVITY;
        ALTER,BLINK20,-1,1;
        ACTIVITY;
        FREE,BLINK20,1;
        ACTIVITY;
        ASSIGN,XX(44)=XX(44)-1,1;
        ACTIVITY,RLOGN(1,.3);
        ASSIGN,XX(49)=XX(49)+1,1;
        ACTIVITY;
        TERMINATE;
DCAB    ASSIGN,XX(44)=XX(44)-1,1;
        ACTIVITY,RLOGN(1,.3);
        ASSIGN,XX(49)=XX(49)+1,1;
        ACTIVITY;
        TERMINATE;
DCAA    GOON,1;
        ACTIVITY;
        ACTIVITY,,ATRIB(9),DCAC;
        GOON,1;
        ACTIVITY,ATRIB(5),ATRIB(6);
        ACTIVITY,,ATRIB(7),DCAD;
        ASSIGN,XX(44)=XX(44)+1,1;
        ACTIVITY;
        TERMINATE;
DCAD    GOON,2;
        ACTIVITY;
        ACTIVITY,,,DS;
        ASSIGN,XX(25)=XX(25)+21.37;
        ACTIVITY,ATRIB(8),,DR;
DCAC    ASSIGN,XX(15)=XX(15)+1,1;
        ACTIVITY,,,DS;
        ACTIVITY;
        TERMINATE;
;
        CREATE,1,,1,1,1;
        ACTIVITY;
DCAE    GOON,1;
        ACTIVITY,0.05,XX(44).LT.1.OR.NNQ(9).EQ.0,DCAE;
        ACTIVITY,,XX(44).GE.1.AND.NNQ(9).GE.1;
        ALTER,BLINK20,1,1;
        ACTIVITY,0.05,,DCAE;
;
;
;       HML AT GRAND FORKS, TREATMENT HLH
;
        CREATE,EXPON(50),,1,,1;
        ACTIVITY/1,RLOGN(1,0.3);
GHML    ASSIGN,ATRIB(10)=RLOGN(51,16),ATRIB(11)=1.0,ATRIB(12)=0.0;
        ASSIGN,ATRIB(6)=0.36,ATRIB(7)=0.64,ATRIB(8)=RLOGN(22,7);
```

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          ASSIGN,ATRIB(9)=0.0,ATRIB(5)=RLOGN(5,1),ATRIB(4)=1,ATRIB(2)=3;
          ASSIGN,XX(55)=XX(55)-1,1;
          ACTIVITY;
          GOON,2;
          ACTIVITY;
          ACTIVITY,,,GHFA;
          GOON,1;
          ACTIVITY,,XX(50).LT.1;
          ACTIVITY,,XX(50).GE.1,GHEX;
          AWAIT(11),BLINK21,,1;
          ACTIVITY;
          ALTER,BLINK21,-1,1;
          ACTIVITY;
          FREE,BLINK21,1;
          ACTIVITY;
          ASSIGN,XX(50)=XX(50)-1,1;
          ACTIVITY,RLOGN(1,0.33);
          ASSIGN,XX(55)=XX(55)+1,1;
          ACTIVITY;
          TERMINATE;
GHEX      ASSIGN,XX(50)=XX(50)-1,1;
          ACTIVITY,RLOGN(1,0.33);
          ASSIGN,XX(55)=XX(55)+1,1;
          ACTIVITY;
          TERMINATE;
GHFA      GOON,1;
          ACTIVITY;
          ACTIVITY,,ATRIB(9),GHEZ;
          GOON,1;
          ACTIVITY,ATRIB(5),ATRIB(6);
          ACTIVITY,,ATRIB(7),GHEY;
          ASSIGN,XX(50)=XX(50)+1,1;
          ACTIVITY;
          TERMINATE;
GHEY      GOON,2;
          ACTIVITY;
          ACTIVITY,,,DS;
          ASSIGN,XX(21)=XX(21)+77.70,1;
          ACTIVITY,ATRIB(8),,DR;
GHEZ      ASSIGN,XX(11)=XX(11)+1,2;
          ACTIVITY,,,DS;
          ACTIVITY;
          TERMINATE;

          CREATE,1,,1,1,1;
          ACTIVITY;
GHGR      GOON,1;
          ACTIVITY,0.05,XX(50).LT.1.OR.NNQ(11).EQ.0,GHGR;
          ACTIVITY,,XX(50).GE.1.AND.NNQ(11).GE.1;
          ALTER,BLINK21,1,1;
          ACTIVITY,.05,,GHGR;
;
;
;
;
;         SPLR AT GRAND FORKS, TREATMENT HLH
;
;
```

```
       CREATE,EXPON(50),,1,,1;
       ACTIVITY/1,RLOGN(1,0.3);
GSPR   ASSIGN,ATRIB(10)=RLOGN(21,6),ATRIB(11)=1.0,ATRIB(12)=0.0;
       ASSIGN,ATRIB(6)=0.68,ATRIB(7)=0.32,ATRIB(8)=RLOGN(22,7);
       ASSIGN,ATRIB(9)=0.0,ATRIB(5)=RLOGN(5,1),ATRIB(4)=2,ATRIB(2)=3;
       ASSIGN,XX(56)=XX(56)-1,1;
       ACTIVITY;
       GOON,2;
       ACTIVITY;
       ACTIVITY,,,GSFA;
       GOON,1;
       ACTIVITY,,XX(51).LT.1;
       ACTIVITY,,XX(51).GE.1,GSEX;
       AWAIT(13),BLINK22,,1;
       ACTIVITY;
       ALTER,BLINK22,-1,1;
       ACTIVITY;
       FREE;BLINK22,1;
       ACTIVITY;
       ASSIGN,XX(51)=XX(51)-1,1;
       ACTIVITY,RLOGN(1,0.33);
       ASSIGN,XX(56)=XX(56)+1,1;
       ACTIVITY;
       TERMINATE;
GSEX   ASSIGN,XX(51)=XX(51)-1,1;
       ACTIVITY,RLOGN(1,0.33);
       ASSIGN,XX(56)=XX(56)+1,1;
       ACTIVITY;
       TERMINATE;
GSFA   GOON,1;
       ACTIVITY;
       ACTIVITY,,ATRIB(9),GHEZ;
       GOON,1;
       ACTIVITY,ATRIB(5),ATRIB(6);
       ACTIVITY,,ATRIB(7),GHEY;
       ASSIGN,XX(51)=XX(51)+1,1;
       ACTIVITY;
       TERMINATE;
GSEY   GOON,2;
       ACTIVITY;
       ACTIVITY,.,DS;
       ASSIGN,XX(22)=XX(22)+124.32,1;
       ACTIVITY,ATRIB(8),,DR;
GSEZ   ASSIGN,XX(12)=XX(12)+1,2;
       ACTIVITY,,,DS;
       ACTIVITY;
       TERMINATE;
;
       CREATE,1,,1,1,1;
       ACTIVITY;
GSGR   GOON,1;
       ACTIVITY,0.05,XX(51).LT.1.OR.NNQ(13).EQ.0,GSGR;
       ACTIVITY,,XX(51).GE.1.AND.NNQ(13).GE.1;
       ALTER,BLINK22,1,1;
       ACTIVITY,.05,,GSGR;
;
;
;      INERT AT GRAND FORKS, TREATMENT HLH
```

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        ;
        ;
        CREATE,EXPON(25),,1,,1;
        ACTIVITY/1,RLOGN(1,0.3);
GNRT    ASSIGN,ATRIB(10)=RLOGN(53,16),ATRIB(11)=1.0,ATRIB(12)=0.0;
        ASSIGN,ATRIB(6)=0.53,ATRIB(7)=0.47,ATRIB(8)=RLOGN(22,7);
        ASSIGN,ATRIB(9)=0.0,ATRIB(5)=RLOGN(5,1),ATRIB(4)=3,ATRIB(2)=3;
        ASSIGN,XX(57)=XX(57)-1,1;
        ACTIVITY;
        GOON,2;
        ACTIVITY;
        ACTIVITY,,,GIFA;
        GOON,1;
        ACTIVITY,,XX(52).LT.1;
        ACTIVITY,,XX(52).GE.1,GIEX;
        AWAIT(15),BLINK23,,1;
        ACTIVITY;
        ALTER,BLINK23,-1,1;
        ACTIVITY;
        FREE,BLINK23,1;
        ACTIVITY;
        ASSIGN,XX(52)=XX(52)-1,1;
        ACTIVITY,RLOGN(1,0.33);
        ASSIGN,XX(57)=XX(57)+1,1;
        ACTIVITY;
        TERMINATE;
GIEX    ASSIGN,XX(52)=XX(52)-1,1;
        ACTIVITY,RLOGN(1,0.33);
        ASSIGN,XX(57)=XX(57)+1,1;
        ACTIVITY;
        TERMINATE;
GIFA    GOON,1;
        ACTIVITY;
        ACTIVITY,,ATRIB(9),GIEZ;
        GOON,1;
        ACTIVITY,ATRIB(5),ATRIB(6);
        ACTIVITY,,ATRIB(7),GIEY;
        ASSIGN,XX(52)=XX(52)+1,1;
        ACTIVITY;
        TERMINATE;
GIEY    GOON,2;
        ACTIVITY;
        ACTIVITY,,,DS;
        ASSIGN,XX(23)=XX(23)+151.52,1;
        ACTIVITY,ATRIB(8),,DR;
GIEZ    ASSIGN,XX(13)=XX(13)+1,2;
        ACTIVITY,,,DS;
        ACTIVITY;
        TERMINATE;
        ;
        CREATE,1,,1,1,1;
        ACTIVITY;
GIGR    GOON,1;
        ACTIVITY,0.05,XX(52).LT.1.OR.NNQ(15).EQ.0,GIGR;
        ACTIVITY,,XX(52).GE.1.AND.NNQ(15).GE.1;
        ALTER,BLINK23,1,1;
        ACTIVITY,.05,,GIGR;
        ;
```

125

```
;
;       FLAP AT GRAND FORKS, TREATMENT HLH
;
;
        CREATE,EXPON(33.33),,1,,1;
        ACTIVITY/1,RLOGN(1,0.3);
GFLP    ASSIGN,ATRIB(10)=RLOGN(23,7),ATRIB(11)=1.0,ATRIB(12)=0.0;
        ASSIGN,ATRIB(6)=0.55,ATRIB(7)=0.45,ATRIB(8)=RLOGN(22,7);
        ASSIGN,ATRIB(9)=0.0,ATRIB(5)=RLOGN(3,.5),ATRIB(4)=4,ATRIB(2)=3;
        ASSIGN,XX(58)=XX(58)-1,1;
        ACTIVITY;
        GOON,2;
        ACTIVITY;
        ACTIVITY,,,GFFA;
        GOON,1;
        ACTIVITY,,XX(53).LT.1;
        ACTIVITY,,XX(53).GE.1,GFEX;
        AWAIT(17),BLINK24,,1;
        ACTIVITY;
        ALTER,BLINK24,-1,1;
        ACTIVITY;
        FREE,BLINK24,1;
        ACTIVITY;
        ASSIGN,XX(53)=XX(53)-1,1;
        ACTIVITY,RLOGN(1,0.33);
        ASSIGN,XX(58)=XX(58)+1,1;
        ACTIVITY;
        TERMINATE;
GFEX    ASSIGN,XX(53)=XX(53)-1,1;
        ACTIVITY,RLOGN(1,0.3);
        ASSIGN,XX(58)=XX(58)+1,1;
        ACTIVITY;
        TERMINATE;
GFFA    GOON,1;
        ACTIVITY;
        ACTIVITY,,ATRIB(9),GFEZ;
        GOON,1;
        ACTIVITY,ATRIB(5),ATRIB(6);
        ACTIVITY,,ATRIB(7),GFEY;
        ASSIGN,XX(53)=XX(53)+1,1;
        ACTIVITY;
        TERMINATE;
GFEY    GOON,2;
        ACTIVITY;
        ACTIVITY,,,DS;
        ASSIGN,XX(24)=XX(24)+93.63,1;
        ACTIVITY,ATRIB(8),,DR;
GFEZ    ASSIGN,XX(14)=XX(14)+1,2;
        ACTIVITY,,,DS;
        ACTIVITY;
        TERMINATE;
;
        CREATE,1,,1,1,1;
        ACTIVITY;
GFGR    GOON,1;
        ACTIVITY,0.05,XX(53).LT.1.OR.NNQ(17).EQ.0,GFGR;
        ACTIVITY,,XX(53).GE.1.AND.NNQ(17).GE.1;
        ALTER,BLINK24,1,1;
```

126

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        ACTIVITY,.05,,GFGR;
;
;
;       CONV AT GRAND FORKS, TREATMENT HLH
;
;
        CREATE,EXPON(16.67),,1,,1;
        ACTIVITY/1,RLOGN(1,0.3);
GCON    ASSIGN,ATRIB(10)=RLOGN(46,15),ATRIB(11)=1.0,ATRIB(12)=0.0;
        ASSIGN,ATRIB(6)=0.73,ATRIB(7)=0.27,ATRIB(8)=RLOGN(22,7);
        ASSIGN,ATRIB(9)=0.0,ATRIB(5)=RLOGN(5,1),ATRIB(4)=5,ATRIB(2)=3;
        ASSIGN,XX(59)=XX(59)-1,1;
        ACTIVITY;
        GOON,2;
        ACTIVITY;
        ACTIVITY,,,GCFA;
        GOON,1;
        ACTIVITY,,XX(54).LT.1;
        ACTIVITY,,XX(54).GE.1,GCEX;
        AWAIT(19),BLINK25,,1;
        ACTIVITY;
        ALTER,BLINK25,-1,1;
        ACTIVITY;
        FREE,BLINK25,1;
        ACTIVITY;
        ASSIGN,XX(54)=XX(54)-1,1;
        ACTIVITY,RLOGN(1,0.33);
        ASSIGN,XX(59)=XX(59)+1,1;
        ACTIVITY;
        TERMINATE;
GCEX    ASSIGN,XX(54)=XX(54)-1,1;
        ACTIVITY,RLOGN(1,0.33);
        ASSIGN,XX(59)=XX(59)+1,1;
        ACTIVITY;
        TERMINATE;
GCFA    GOON,1;
        ACTIVITY;
        ACTIVITY,,ATRIB(9),GCEZ;
        GOON,1;
        ACTIVITY,ATRIB(5),ATRIB(6);
        ACTIVITY,,ATRIB(7),GCEY;
        ASSIGN,XX(54)=XX(54)+1,1;
        ACTIVITY;
        TERMINATE;
GCEY    GOON,2;
        ACTIVITY;
        ACTIVITY,,,DS;
        ASSIGN,XX(25)=XX(25)+128.21,1;
        ACTIVITY,ATRIB(8),,DR;
GCEZ    ASSIGN,XX(15)=XX(15)+1,2;
        ACTIVITY,,,DS;
        ACTIVITY;
        TERMINATE;
;
        CREATE,1,,1,1,1;
        ACTIVITY;
GCGR    GOON,1;
        ACTIVITY,0.05,XX(54).LT.1.OR.NNQ(19).EQ.0,GCGR;
```

127

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                ACTIVITY,,XX(54).GE.1.AND.NNQ(19).GE.1;
                ALTER,BLINK25,1,1;
                ACTIVITY,.05,,GCGR;
;
;
;       HML AT McCONNELL, TREATMENT HLH
;
                CREATE,EXPON(50),,1,,1;
                ACTIVITY/1,RLOGN(1,0.3);
MHML    ASSIGN,ATRIB(10)=RLOGN(51,16),ATRIB(11)=1.0,ATRIB(12)=0.0;
                ASSIGN,ATRIB(6)=0.36,ATRIB(7)=0.64,ATRIB(8)=RLOGN(22,7);
                ASSIGN,ATRIB(9)=0.0,ATRIB(5)=RLOGN(5,1),ATRIB(4)=1,ATRIB(2)=4;
                ASSIGN,XX(65)=XX(65)-1,1;
                ACTIVITY;
                GOON,2;
                ACTIVITY;
                ACTIVITY,,,MHFA;
                GOON,1;
                ACTIVITY,,XX(60).LT.1;
                ACTIVITY,,XX(60).GE.1,MHEX;
                AWAIT(21),BLINK26,,1;
                ACTIVITY;
                ALTER,BLINK26,-1,1;
                ACTIVITY;
                FREE,BLINK26,1;
                ACTIVITY;
                ASSIGN,XX(60)=XX(60)-1,1;
                ACTIVITY,RLOGN(1,0.33);
                ASSIGN,XX(65)=XX(65)+1,1;
                ACTIVITY;
                TERMINATE;
MHEX    ASSIGN,XX(60)=XX(60)-1,1;
                ACTIVITY,RLOGN(1,0.33);
                ASSIGN,XX(65)=XX(65)+1,1;
                ACTIVITY;
                TERMINATE;
MHFA    GOON,1;
                ACTIVITY;
                ACTIVITY,,ATRIB(9),MHEZ;
                GOON,1;
                ACTIVITY,ATRIB(5),ATRIB(6);
                ACTIVITY,,ATRIB(7),MHEY;
                ASSIGN,XX(60)=XX(60)+1,1;
                ACTIVITY;
                TERMINATE;
MHEY    GOON,2;
                ACTIVITY;
                ACTIVITY,,,DS;
                ASSIGN,XX(21)=XX(21)+18.13,1;
                ACTIVITY,ATRIB(8),,DR;
MHEZ    ASSIGN,XX(11)=XX(11)+1,2;
                ACTIVITY,,,DS;
                ACTIVITY;
                TERMINATE;

                CREATE,1,,1,1,1;
                ACTIVITY;
MHGR    GOON,1;
```

```
        ACTIVITY,0.05,XX(60).LT.1.OR.NNQ(21).EQ.0,MHGR;
        ACTIVITY,,XX(60).GE.1.AND.NNQ(21).GE.1;
        ALTER,BLINK26,1,1;
        ACTIVITY,.05,,MHGR;
;
;
;
;
;       SPLR AT MCCONNELL, TREATMENT HLH
;
;
        CREATE,EXPON(50),,1,,1;
        ACTIVITY/1,RLOGN(1,0.3);
MSPR    ASSIGN,ATRIB(10)=RLOGN(21,6),ATRIB(11)=1.0,ATRIB(12)=0.0;
        ASSIGN,ATRIB(6)=0.68,ATRIB(7)=0.32,ATRIB(8)=RLOGN(22,7);
        ASSIGN,ATRIB(9)=0.0,ATRIB(5)=RLOGN(5,1),ATRIB(4)=2,ATRIB(2)=4;
        ASSIGN,XX(66)=XX(66)-1,1;
        ACTIVITY;
        GOON,2;
        ACTIVITY;
        ACTIVITY,,,MSFA;
        GOON,1;
        ACTIVITY,,XX(61).LT.1;
        ACTIVITY,,XX(61).GE.1,MSEX;
        AWAIT(23),BLINK27,,1;
        ACTIVITY;
        ALTER,BLINK27,-1,1;
        ACTIVITY;
        FREE,BLINK27,1;
        ACTIVITY;
        ASSIGN,XX(61)=XX(61)-1,1;
        ACTIVITY,RLOGN(1,0.33);
        ASSIGN,XX(66)=XX(66)+1,1;
        ACTIVITY;
        TERMINATE;
MSEX    ASSIGN,XX(61)=XX(61)-1,1;
        ACTIVITY,RLOGN(1,0.33);
        ASSIGN,XX(66)=XX(66)+1,1;
        ACTIVITY;
        TERMINATE;
MSFA    GOON,1;
        ACTIVITY;
        ACTIVITY,,ATRIB(9),MHEZ;
        GOON,1;
        ACTIVITY,ATRIB(5),ATRIB(6);
        ACTIVITY,,ATRIB(7),MHEY;
        ASSIGN,XX(61)=XX(61)+1,1;
        ACTIVITY;
        TERMINATE;
MSEY    GOON,2;
        ACTIVITY;
        ACTIVITY,,,DS;
        ASSIGN,XX(22)=XX(22)+29.01,1;
        ACTIVITY,ATRIB(8),,DR;
MSEZ    ASSIGN,XX(12)=XX(12)+1,2;
        ACTIVITY,,,DS;
        ACTIVITY;
        TERMINATE;
```

```
      ;
            CREATE,1,,1,1,1;
            ACTIVITY;
MSGR    GOON,1;
            ACTIVITY,0.05,XX(61).LT.1.OR.NNQ(23).EQ.0,MSGR;
            ACTIVITY,,XX(61).GE.1.AND.NNQ(23).GE.1;
            ALTER,BLINK27,1,1;
            ACTIVITY,.05,,MSGR;
      ;
      ;
      ;     INERT AT MCCONNELL,  TREATMENT HLH
      ;
      ;
            CREATE,EXPON(20),,1,,1;
            ACTIVITY/1,RLOGN(1,0.3);
MNRT    ASSIGN,ATRIB(10)=RLOGN(53,17),ATRIB(11)=1.0,ATRIB(12)=0.0;
            ASSIGN,ATRIB(6)=0.53,ATRIB(7)=0.47,ATRIB(8)=RLOGN(22,7);
            ASSIGN,ATRIB(9)=0.0,ATRIB(5)=RLOGN(5,1),ATRIB(4)=3,ATRIB(2)=4;
            ASSIGN,XX(67)=XX(67)-1,1;
            ACTIVITY;
            GOON,2;
            ACTIVITY;
            ACTIVITY,,,MIFA;
            GOON,1;
            ACTIVITY,,XX(62).LT.1;
            ACTIVITY,,XX(62).GE.1,MIEX;
            AWAIT(25),BLINK28,,1;
            ACTIVITY;
            ALTER,BLINK28,-1,1;
            ACTIVITY;
            FREE,BLINK28,1;
            ACTIVITY;
            ASSIGN,XX(62)=XX(62)-1,1;
            ACTIVITY,RLOGN(1,0.33);
            ASSIGN,XX(67)=XX(67)+1,1;
            ACTIVITY;
            TERMINATE;
MIEX    ASSIGN,XX(62)=XX(62)-1,1;
            ACTIVITY,RLOGN(1,0.33);
            ASSIGN,XX(67)=XX(67)+1,1;
            ACTIVITY;
            TERMINATE;
MIFA    GOON,1;
            ACTIVITY;
            ACTIVITY,,ATRIB(9),MIEZ;
            GOON,1;
            ACTIVITY,ATRIB(5),ATRIB(6);
            ACTIVITY,,ATRIB(7),MIEY;
            ASSIGN,XX(62)=XX(62)+1,1;
            ACTIVITY;
            TERMINATE;
MIEY    GOON,2;
            ACTIVITY;
            ACTIVITY,,,DS;
            ASSIGN,XX(23)=XX(23)+35.35,1;
            ACTIVITY,ATRIB(8),,DR;
MIEZ    ASSIGN,XX(13)=XX(13)+1,2;
            ACTIVITY,,,DS;
```

130

```
        ACTIVITY;
        TERMINATE;
;
        CREATE,1,,1,1,1;
        ACTIVITY;
MIGR    GOON,1;
        ACTIVITY,0.05,XX(62).LT.1.OR.NNQ(25).EQ.0,MIGR;
        ACTIVITY,,XX(62).GE.1.AND.NNQ(25).GE.1;
        ALTER,BLINK28,1,1;
        ACTIVITY,.05,,MIGR;
;
;       FLAP AT MCCONNELL, TREATMENT HLH
;
;
        CREATE,EXPON(33.33),,1,,1;
        ACTIVITY/1,RLOGN(1,0.3);
MFLP    ASSIGN,ATRIB(10)=RLOGN(23,7),ATRIB(11)=1.0,ATRIB(12)=0.0;
        ASSIGN,ATRIB(6)=0.55,ATRIB(7)=0.45,ATRIB(8)=RLOGN(22,7);
        ASSIGN,ATRIB(9)=0.0,ATRIB(5)=RLOGN(3,.5),ATRIB(4)=4,ATRIB(2)=4;
        ASSIGN,XX(68)=XX(68)-1,1;
        ACTIVITY;
        GOON,2;
        ACTIVITY;
        ACTIVITY,,,MFFA;
        GOON,1;
        ACTIVITY,,XX(63).LT.1;
        ACTIVITY,,XX(63).GE.1,MFEX;
        AWAIT(27),BLINK29,,1;
        ACTIVITY;
        ALTER,BLINK29,-1,1;
        ACTIVITY;
        FREE,BLINK29,1;
        ACTIVITY;
        ASSIGN,XX(63)=XX(63)-1,1;
        ACTIVITY,RLOGN(1,0.33);
        ASSIGN,XX(68)=XX(68)+1,1;
        ACTIVITY;
        TERMINATE;
MFEX    ASSIGN,XX(63)=XX(63)-1,1;
        ACTIVITY,RLOGN(1,0.33);
        ASSIGN,XX(68)=XX(68)+1,1;
        ACTIVITY;
        TERMINATE;
MFFA    GOON,1;
        ACTIVITY;
        ACTIVITY,,ATRIB(9),MFEZ;
        GOON,1;
        ACTIVITY,ATRIB(5),ATRIB(6);
        ACTIVITY,,ATRIB(7),MFEY;
        ASSIGN,XX(63)=XX(63)+1,1;
        ACTIVITY;
        TERMINATE;
MFEY    GOON,2;
        ACTIVITY;
        ACTIVITY,,,DS;
        ASSIGN,XX(24)=XX(24)+21.85,1;
        ACTIVITY,ATRIB(8),,DR;
MFEZ    ASSIGN,XX(14)=XX(14)+1,2;
```

```
        ACTIVITY,,,DS;
        ACTIVITY;
        TERMINATE;
;
        CREATE,1,,1,1,1;
        ACTIVITY;
MFGR    GOON,1;
        ACTIVITY,0.05,XX(63).LT.1.OR.NNQ(27).EQ.0,MFGR;
        ACTIVITY,,XX(63).GE.1.AND.NNQ(27).GE.1;
        ALTER,BLINK29,1,1;
        ACTIVITY,.05,,MFGR;
;
;
;       CONV AT MCCONNELL, TREATMENT HLH
;
;
        CREATE,EXPON(16.67),,1,,1;
        ACTIVITY/1,RLOGN(1,0.3);
MCON    ASSIGN,ATRIB(10)=RLOGN(46,15),ATRIB(11)=1.0,ATRIB(12)=0.0;
        ASSIGN,ATRIB(6)=0.73,ATRIB(7)=0.27,ATRIB(8)=RLOGN(22,7);
        ASSIGN,ATRIB(9)=0.0,ATRIB(5)=RLOGN(5,1),ATRIB(4)=5,ATRIB(2)=4;
        ASSIGN,XX(69)=XX(69)-1,1;
        ACTIVITY;
        GOON,2;
        ACTIVITY;
        ACTIVITY,,,MCFA;
        GOON,1;
        ACTIVITY,,XX(64).LT.1;
        ACTIVITY,,XX(64).GE.1,MCEX;
        AWAIT(29),BLINK30,,1;
        ACTIVITY;
        ALTER,BLINK30,-1,1;
        ACTIVITY;
        FREE,BLINK30,1;
        ACTIVITY;
        ASSIGN,XX(64)=XX(64)-1,1;
        ACTIVITY,RLOGN(1,0.33);
        ASSIGN,XX(69)=XX(69)+1,1;
        ACTIVITY;
        TERMINATE;
MCEX    ASSIGN,XX(64)=XX(64)-1,1;
        ACTIVITY,RLOGN(1,0.33);
        ASSIGN,XX(69)=XX(69)+1,1;
        ACTIVITY;
        TERMINATE;
MCFA    GOON,1;
        ACTIVITY;
        ACTIVITY,,ATRIB(9),MCEZ;
        GOON,1;
        ACTIVITY,ATRIB(5),ATRIB(6);
        ACTIVITY,,ATRIB(7),MCEY;
        ASSIGN,XX(64)=XX(64)+1,1;
        ACTIVITY;
        TERMINATE;
MCEY    GOON,2;
        ACTIVITY;
        ACTIVITY,,,DS;
        ASSIGN,XX(25)=XX(25)+29.91,1;
```

```
        ACTIVITY,ATRIB(8),,DR;
MCEZ    ASSIGN,XX(15)=XX(15)+1,2;
        ACTIVITY,,,DS;
        ACTIVITY;
        TERMINATE;
;
        CREATE,1,,1,1,1;
        ACTIVITY;
MCGR    GOON,1;
        ACTIVITY,0.05,XX(64).LT.1.OR.NNQ(29).EQ.0,MCGR;
        ACTIVITY,,XX(64).GE.1.AND.NNQ(29).GE.1;
        ALTER,BLINK30,1,1;
        ACTIVITY,.05,,MCGR;
;
        END;
MONTR,CLEAR,730;
SEEDS,1048015(1)/YES;
SIMULATE;
MONTR,CLEAR,730;
SEEDS,2236846(1)/YES;
SIMULATE;
MONTR,CLEAR,730;
SEEDS,2413048(1)/YES;
SIMULATE;
MONTR,CLEAR,730;
SEEDS,4216793(1)/YES;
SIMULATE;
MONTR,CLEAR,730;
SEEDS,3757039(1)/YES;
SIMULATE;
MONTR,CLEAR,730;
SEEDS,7792106(1)/YES;
SIMULATE;
MONTR,CLEAR,730;
SEEDS,9956272(1)/YES;
SIMULATE;
MONTR,CLEAR,730;
SEEDS,9630191(1)/YES;
SIMULATE;
MONTR,CLEAR,730;
SEEDS,8957914(1)/YES;
SIMULATE;
MONTR,CLEAR,730;
SEEDS,8547536(1)/YES;
SIMULATE;
MONTR,CLEAR,730;
SEEDS,2891869(1)/YES;
SIMULATE;
MONTR,CLEAR,730;
SEEDS,6355340(1)/YES;
SIMULATE;
MONTR,CLEAR,730;
SEEDS,0942993(1)/YES;
SIMULATE;
MONTR,CLEAR,730;
SEEDS,1036561(1)/YES;
SIMULATE;
MONTR,CLEAR,730;
```

```
SEEDS,0711997(1)/YES;
SIMULATE;
MONTR,CLEAR,730;
SEEDS,5108512(1)/YES;
SIMULATE;
MONTR,CLEAR,730;
SEEDS,0236821(1)/YES;
SIMULATE;
MONTR,CLEAR,730;
SEEDS,0101154(1)/YES;
SIMULATE;
MONTR,CLEAR,730;
SEEDS,5216253(1)/YES;
SIMULATE;
MONTR,CLEAR,730;
SEEDS,0705697(1)/YES;
SIMULATE;
MONTR,CLEAR,730;
SEEDS,4866391(1)/YES;
SIMULATE;
MONTR,CLEAR,730;
SEEDS,5416458(1)/YES;
SIMULATE;
MONTR,CLEAR,730;
SEEDS,3263932(1)/YES;
SIMULATE;
MONTR,CLEAR,730;
SEEDS,2933427(1)/YES;
SIMULATE;
MONTR,CLEAR,730;
SEEDS,0248833(1)/YES;
SIMULATE;
MONTR,CLEAR,730;
SEEDS,8152572(1)/YES;
SIMULATE;
MONTR,CLEAR,730;
SEEDS,2967620(1)/YES;
SIMULATE;
MONTR,CLEAR,730;
SEEDS,0074257(1)/YES;
SIMULATE;
MONTR,CLEAR,730;
SEEDS,0536604(1)/YES;
SIMULATE;
MONTR,CLEAR,730;
SEEDS,9192126(1)/YES;
FIN;
```

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Appendix C: Description of the Simulation Model

Introduction

This appendix provides a basic description of the simulation model logic. The code and corresponding graphical representations discussed in this appendix are representative of the code as a whole. Many portions of the code repeat the same basic structure and use similar lines of code with only minor differences. The graphical representations are provided merely for ease of understanding. The actual experimental design involved reproducing the code found in Appendix B twenty seven times, with minor differences (one model for each treatment of the experimental design).

Attributes, Files, and Global Variables

The following tables show the attributes, files, and global variables used in the simulation code.

Table C-1. Attributes Used in the Simulation Code.

Attribute	Attribute Definition
1	Mark Time
2	Base where the entity originated
4	Type of reparable, i.e. HML, SPLR, INERT, FLAP, or CONV
5	Base repair cycle time
6	Percent base repair
7	Base NRTS rate
8	Transportation time
9	Base condemnation rate
10	Depot repair cycle time
11	Percent depot repair
12	Depot condemnation rate
13	# new assets needed to replace condemned reparables

Table C-2.   Files Used in the Simulation Code.

File Number	Purpose of File
2	HML entities ar *Ellsworth* AWAIT resource BLINK1
4	SPLR entities ar Ellsworth AWAIT resource BLINK2
6	INERT entities ar Ellsworth AWAIT resource BLINK3
8	FLAP entities ar Ellsworth AWAIT resource BLINK4
10	CONV entities ar Ellsworth AWAIT resource BLINK5
12	HML entities at *Depot/ISP supply* AWAIT BLINK6
14	SPLR entities at Depot/ISP supply AWAIT BLINK7
16	INERT entities at Depot/ISP supply AWAIT BLINK8
18	FLAP entities at Depot/ISP supply AWAIT BLINK9
20	CONV entities at Depot/ISP supply AWAIT BLINK10
22	HML entities at *Depot repair* AWAIT BLINK11
24	SPLR entities at *Depot repair* AWAIT BLINK12
26	INERT entities at *Depot repair* AWAIT RLINK13
28	FLAP entities at *Depot repair* AWAIT BLINK14
30	CONV entities at *Depot repair* AWAIT BLINK15
1	HML entities at *Dyess* AWAIT resource BLINK16
3	SPLR entities at *Dyess* AWAIT resource BLINK17
5	INERT entities at *Dyess* AWAIT resource BLINK18
7	FLAP entities at *Dyess* AWAIT resource BLINK19
9	CONV entities at *Dyess* AWAIT resource BLINK20
11	HML entities at *Grand Fks* AWAIT resource BLINK21
13	SPLR entities at *Grand Fks* AWAIT resource BLINK22
15	INERT entities at *Grand Fks* AWAIT resrce BLINK23
17	FLAP entities at *Grand Fks* AWAIT resource RLINK24
19	CONV entities at *Grand Fks* AWAIT resrce BLINK25
21	HML entities at *McConnell* AWAIT resource BLINK26
23	SPLR entities at *McConnell* AWAIT resource BLINK27
25	INERT entities at *McCnnl* AWAIT resource BLINK28
27	FLAP entities at *McCnnl* AWAIT resource BLINK29
29	CONV entities at *McCnnl* AWAIT resource BLINK30

Table C-3. Global Variables Used in the Simulation Code.

XX(n)	Global Variable Definition
1	# of serviceable HMLS in the fleet at Ellsworth
7	# of serviceable SPLRS in the fleet at Ellsworth
8	# of serviceable INERTS in the fleet at Ellsworth
9	# of serviceable FLAPS in the fleet at Ellsworth
10	# of serviceable CONVS in the fleet at Ellsworth
2	# of serviceable HMLs at Ellsworth base supply
3	# of serviceable SPLRS at Ellsworth base supply
4	# of serviceable INERTS at Ellsworth base supply
5	# of serviceable FLAPS at Ellsworth base supply
6	# of serviceable CONVS at Ellsworth base supply
11	# of HMLScondemned from the system
12	# of SPLRS condemned from the system
13	# of INERTS condemned from the system
14	# of FLAPS condemned from the system
15	# of CONVS condemned from the system
21	Transportation cost for HMLS between bases and the Depot/ISP
22	Transportation cost for SPLRS between bases and the Depot/ISP
23	Transportation cost for INERTS between bases and the Depot/ISP
24	Transportation cost for FLAPS between bases and the Depot/ISP
25	Transportation cost for CONVS between bases and the Depot/ISP
31	# serviceable HMLS at the Depot/ISP supply
32	# serviceable SPLRS at the Depot/ISP supply
33	# serviceable INERTS at the Depot/ISP supply
34	# serviceable FLAPS at the Depot/ISP supply
35	# serviceable CONVS at the Depot/ISP supply
40	# of serviceable HMLS at Dyess base supply
41	# of serviceable SPLRS at Dyess base supply
42	# of serviceable INERTS at Dyess base supply
43	# of serviceable FLAPS at Dyess base supply
44	# of serviceable CONVS at Dyess base supply
45	# of serviceable HMLS in the fleet at Dyess
46	# of serviceable SPLRS in the fleet at Dyess
47	# of serviceable INERTS in the fleet at Dyess
48	# of serviceable FLAPS in the fleet at Dyess
49	# of serviceable CONVS in the fleet at Dyess
50	# of serviceable HMLS at Grnd Fks base supply

139

51	# of serviceable **SPLRS** at Grnd Fks base supply
52	# of serviceable **INERTS** at Grnd Fks base supply
53	# of serviceable **FLAPS** at Grnd Fks base supply
54	# of serviceable **CONVS** at Grnd Fks base supply
55	# of serviceable **HMLS** in the fleet at Grnd Fks
56	# of serviceable **SPLRS** in the fleet at Grnd Fks
57	# of serviceable **INERTS** in the fleet at Grnd Fks
58	# of serviceable **FLAPS** in the fleet at Grnd Fks
59	# of serviceable **CONVS** in the fleet at Grnd Fks
60	# of serviceable **HMLS** at McConnell base supply
61	# of serviceable **SPLRS** at McConnell base supply
62	# of serviceable **INERTS** at McConnell base supply
63	# of serviceable **FLAPS** at McConnell base supply
64	# of serviceable **CONVS** at McConnell base supply
65	# of serviceable **HMLS** in the fleet at McConnell
66	# of serviceable **SPLRS** in the fleet at McConnell
67	# of serviceable **INERTS** in the fleet at McConnell
68	# of serviceable **FLAPS** in the fleet at McConnell
69	# of serviceable **CONVS** in the fleet at McConnell
101	Average acft availabilty at Ellsworth
102	Average acft availabilty at Dyess
103	Average acft availabilty at Grand Forks
104	Average acft availabilty at McConnell
105	Average acft availabilty across all bases
106	Average fill rate at Ellsworth
107	Average fill rate at Dyess
108	Average fill rate at Grand Forks
109	Average fill rate at McConnell
110	Average fill rate across all bases
111	Average fill rate at Depot
112	Total transportation cost for all assets, all bases

Model Description

Control Statements. Refer to Figure C-1 for the following discussion. Lines 1 through 17 are merely the

necessary control statements that SLAM II uses to set up the
run.

```
 1    GEN,HILLWALKER,TESTHHH,31/7/1994,10,Y,Y,Y/Y,Y,Y/1,72;
 2    LIMITS,30,20,15000;
 3    INITIALIZE,,1095,Y;
 4    INTLC,XX(2)=1,XX(3)=1,XX(4)=3,XX(5)=2,XX(6)=3;
 5    INTLC,XX(31)=5,XX(32)=3,XX(33)=14,XX(34)=6,XX(35)=11;
 6    INTLC,XX(40)=2,XX(41)=2,XX(42)=3,XX(43)=2,XX(44)=3;
 7    INTLC,XX(50)=1,XX(51)=1,XX(52)=2,XX(53)=1,XX(54)=2;
 8    INTLC,XX(60)=1,XX(61)=1,XX(62)=2,XX(63)=1,XX(64)=2;
 9    INTLC,XX(1)=24,XX(7)=24,XX(8)=24,XX(9)=24,XX(10)=24;
10    INTLC,XX(45)=28,XX(46)=28,XX(47)=28,XX(48)=28,XX(49)=28;
11    INTLC,XX(55)=16,XX(56)=16,XX(57)=16,XX(58)=16,XX(59)=16;
12    INTLC,XX(65)=16,XX(66)=16,XX(67)=16,XX(68)=16,XX(69)=16;
13    TIMST,XX(105),EST PCFT AVAIL;
14    TIMST,XX(110),AV BS FILL RATE;
15    TIMST,XX(111),AV DS FILL RATE;
16    TIMST,XX(112), TRANS COST;
17    NETWORK;
```

Figure C-1.   Simulation Model Control Statements.

Initialize Statements.   Refer to Figure C-1, above, for
the following discussion.   Lines 4 through 12 of the code
initialize the global variables of interest.   The tables
above define all the variables.   Line 4 initializes the
number of parts at Ellsworth base supply.   Line 5
initializes the number of parts at depot supply/ISP.   Line 6
initializes the number of parts at Dyess base suppy.   Line 7
initializes the number of parts at Grand Forks base supply.
Line 8 initializes the number of parts at McConnell base
supply.   Line 9 initializes the number of parts in the fleet
at Ellsworth.   Line 10 initializes the number of parts in
the fleet at Dyess.   Line 11 initializes the number of parts
in the fleet at Grand Forks.   Line 12 initializes the number
of parts in the fleet at McConnell.

```
18        RESOURCE/1,BLINK1(0),2;
19        RESOURCE/2,BLINK2(0),4;
20        RESOURCE/3,BLINK3(0),6;
21        RESOURCE/4,BLINK4(0),8;
22        RESOURCE/5,BLINK5(0),10;
23        RESOURCE/6,BLINK6(0),12;
24        RESOURCE/7,BLINK7(0),14;
25        RESOURCE/8,BLINK8(0),16;
26        RESOURCE/9,BLINK9(0),18;
27        RESOURCE/10,BLINK10(0),20;
28        RESOURCE/11,BLINK11(0),22;
29        RESOURCE/12,BLINK12(0),24;
30        RESOURCE/13,BLINK13(0),26;
31        RESOURCE/14,BLINK14(0),28;
32        RESOURCE/15,BLINK15(0),30;
33        RESOURCE/16,BLINK16(0),1;
34        RESOURCE/17,BLINK17(0),3;
35        RESOURCE/18,BLINK18(0),5;
36        RESOURCE/19,BLINK19(0),7;
37        RESOURCE/20,BLINK20(0),9;
38        RESOURCE/21,BLINK21(0),11;
39        RESOURCE/22,BLINK22(0),13;
40        RESOURCE/23,BLINK23(0),15;
41        RESOURCE/24,BLINK24(0),17;
42        RESOURCE/25,BLINK25(0),19;
43        RESOURCE/26,BLINK26(0),21;
44        RESOURCE/27,BLINK27(0),23;
45        RESOURCE/28,BLINK28(0),25;
46        RESOURCE/29,BLINK29(0),27;
47        RESOURCE/30,BLINK30(0),29;
```

Figure C-2. Resource Statements of the Simulation Model.

Resources. Refer to Figure C-2, above, for the
following discussion. The resource statements set the
initial levels of the resources used in the model's "blinker
mechanisms." The details of how the resource and "blinker
mechanism" combination works will be explained in a later
section of this apendix.

Computation of Dependent Variables. Refer to Figure __
for the following discussion. Lines 51 tnrough 66 are the
algebraic formulas used to compute the dependent variables.

142

Line 51 causes the computations to be performed every 7

simulated days.   Lines 53 through 56

```
   51        CREATE,7,7,,,;
   52        ACTIVITY;
   53        ASSIGN,XX(101)=XX(1)*XX(7)*XX(8)*XX(9)*XX(10)/7962624;
   54        ASSIGN,XX(102)=XX(45)*XX(46)*XX(47)*XX(48)*XX(49)/17210368;
   55        ASSIGN,XX(103)=XX(55)*XX(56)*XX(57)*XX(58)*XX(59)/1048576;
   56        ASSIGN,XX(104)=XX(65)*XX(66)*XX(67)*XX(68)*XX(69)/1048576;
   57        ASSIGN,XX(105)=XX(101)/4+XX(102)/4+XX(103)/4+XX(104)/4;
   58        ASSIGN,XX(106)=XX(2)/5+XX(3)/5+XX(4)/15+XX(5)/10+XX(6)/15;
   59
ASSIGN,XX(107)=XX(40)/10+XX(41)/10+XX(42)/15+XX(43)/10+XX(44)/15;
   60        ASSIGN,XX(108)=XX(50)/5+XX(51)/5+XX(52)/10+XX(53)/5+XX(54)/10;
   61        ASSIGN,XX(109)=XX(60)/5+XX(61)/5+XX(62)/10+XX(63)/5+XX(64)/10;
   62        ASSIGN,XX(110)=XX(106)/4+ XX(107)/4+XX(108)/4+XX(109)/4;
   63
ASSIGN,XX(111)=XX(31)/20+XX(32)/10+XX(33)/45+XX(34)/20+XX(35)/35;
   64        ASSIGN,XX(112)=XX(21)+XX(22)+XX(23)+XX(24)+XX(25);
   65        ACTIVITY;
   66        TERMINATE;
```

Figure C-3.   Computation of Dependent Variables.

compute aircraft availability for Ellsworth, Dyess, Grand

Forks, and McConnell, respectively.   Line 57 computes

aircraft availability across all the bases.   Lines 58 though

63 were not needed.   Line 64 totals transportation costs for

all assets in the system.

Asset Activity at the Base Level.   Refer to Figures C-4

and C-5 for the following discussion.   This set of code was

repeated with minor differences for each of the five assets

of interest at each of the four bases.   Line 70 creates a

demand for a part (think of it as a broken part on the

aircraft) based on the distribution and interarrival time.

The broken part is removed from the aircraft in line 71.

Lines 72 through 74 assign various attibutes to the broken

part that will be used downstream in the simuiation model.

143

These attributes change from treatment to treatment, asset
to asset.

```
 70         CREATE,EXPON(33.33),,1,,1;
 71         ACTIVITY/1,RLOGN(1,0.3);
 72   EHML  ASSIGN,ATRIB(10)=RLOGN(51,16),ATRIB(11)=1.0,ATRIB(12)=0.0;
 73         ASSIGN,ATRIB(6)=0.36,ATRIB(7)=0.64,ATRIB(8)=RLOGN(22,7);
 74         ASSIGN,ATRIB(9)=0.0,ATRIB(5)=RLOGN(5,1),ATRIB(4)=1,ATRIB(2)=1;
 75         ASSIGN,XX(1)=XX(1)-1,1;
 76         ACTIVITY;
 77         GOON,2;
 78         ACTIVITY/2;
 79         ACTIVITY/3,,,EHAA;
 80         GOON,1;
 81         ACTIVITY/4,,XX(2).LT.1;
 82         ACTIVITY/5,,XX(2).GE.1,EHAB;
 83         AWAIT(2),BLINK1,,1;
 84         ACTIVITY;
 85         ALTER,BLINK1,-1,1;
 86         ACTIVITY;
 87         FREE,BLINK1,1;
 88         ACTIVITY;
 89         ASSIGN,XX(2)=XX(2)-1,1;
 90         ACTIVITY/6,RLOGN(1,0.33);
 91         ASSIGN,XX(1)=XX(1)+1,1;
 92         ACTIVITY;
 93         TERMINATE;
 94   EHAB  ASSIGN,XX(2)=XX(2)-1,1;
 95         ACTIVITY/7,RLOGN(1,0.33);
 96         ASSIGN,XX(1)=XX(1)+1,1;
 97         ACTIVITY;
 98         TERMINATE;
 99   EHAA  GOON,1;
100         ACTIVITY/8;
101         ACTIVITY/9,,ATRIB(9),EHAC;
102         GOON,1;
103         ACTIVITY/10,ATRIB(5),ATRIB(6);
104         ACTIVITY/11,,ATRIB(7),EHAD;
105         ASSIGN,XX(2)=XX(2)+1,1;
106         ACTIVITY;
107         TERMINATE;
108   EHAD  GOON,2;
109         ACTIVITY;
110         ACTIVITY/13,,,DS;
111         ASSIGN,XX(21)=XX(21)+77.70,1;
112         ACTIVITY/12,ATRIB(8),,DR;
113   EHAC  ASSIGN,XX(11)=XX(11)+1,2;
114         ACTIVITY/14,,,DS;
115         ACTIVITY/15;
116         TERMINATE;
```

Figure C-4.   Asset Activity at the Base Level.

144
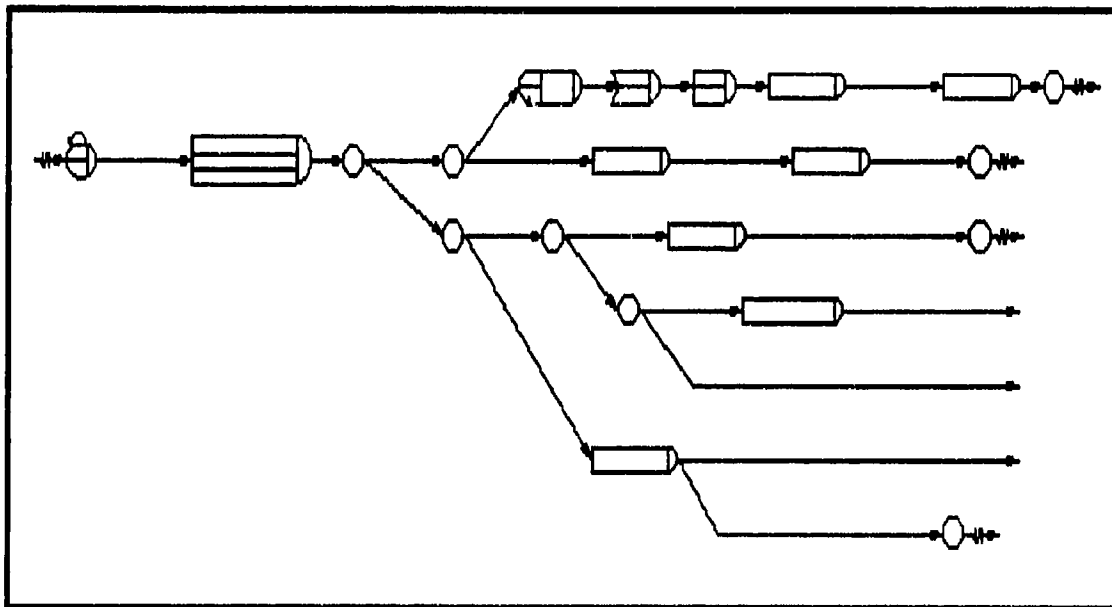
Figure C-5. Graphical Representation of Asset Activity at Base Level.

The following is a list of characteristics assigned at this point:

Depot repair cycle time	Percent depot repair
Depot condemnation rate	Percent base repair
Base NRTS rate	Transportation time
Base condemnation rate	Base repair cycle time
Asset allocation	Base allocation

After the necessary assignments have been made, the number of serviceable parts in the aircraft fleet is incremented in line 75. In line 77 the broken part is "split" into two entities, one which represents the requisition to base supply for a serviceable replacement

part, and the other that continues as the broken asset. The broken part is sent to the base repair cycle via line 79.

Requisition path. The requisition takes line 81 if there is no spare asset available on the shelf at base supply. The requisition takes line 82 if there is a spare on the shelf at base supply. Line 83 causes requisitions to queue up FIFO and wait for the "blinker mechanism" to allow one requisition to be processed. As soon as a requisistion is allowed to be processed, lines 84 through 88 resets the resource used in the "blinker mechanism" to it original level. Once the requisition is allowed to be processed, a part is taken off the shelf at base supply. Line 89 decrements the number of spares on the shelf at base supply. The serviceable asset is then intalled in the aircraft via line 90 and line 91 then increments the number of serviceable assets in the fleet at the base.

If, when the part broke in the aircraft, a spare was avilable at base supply, the requisition jumps from line 82 down to line 94 where the spare is removed from the shelf at base supply and the number of spares on the shelf is decremented. The serviceable part is then installed in the aircraft in line 95. And the number of serviceable assets in the fleet at the base is incremented in line 96.

As stated previously, the broken parts, after being removed from the aircraft, are sent to the base repair cycle. The repair cycle starts at line 99. If the broken

part is to be condemned, it takes line 101. If the broken part will not be condemned, it gets repaired in line 103. If the part cannot be repaired at the base level, if takes line 104 where it is NRTS to depot repair. If the broken part was repaired at the base level, it jumps down from line 103 to line 105 where it is placed on the shelf at base supply and the number of spare on the shelf is incremented.

If the broken part could not be repaired at the base level, it jumps down from line 104 to line 108. Once again the broken part is "split" into a requisition and a broken part. The requisition for a replenishment asset is sent to depot supply via line 110. The broken part triggers line 111 where its transportation cost is tallied. The broken part is then sent to depot repair via line 112.

If the broken part was condemned at the base level, it jumps down from line 101 to line 113 where it is counted, and condemned (line115 and 116). When a broken part is condemend a replenishment part is requisitioned from the depot supply. This is done in line 114.

Blinker Mechanism. Refer to Figure C-6 for the following discussion. Line 118 sends one entity through this small network to repeatedly check the conditions in lines 121 and 122. For example, in line 122, a requisition queued up in base supply is allowed to be processed if there is a spare on the shelf and there is a requisition in the

queue. Otherwise, line 121 causes the entity to cycle
around and check again a short time later.

```
118          CREATE,1,,1,1,1;
119          ACTIVITY;
120   EHAE   GOON,1;
121          ACTIVITY,0.05,XX(2).LT.1.OR.NNQ(2).EQ.0,EHAE;
122          ACTIVITY,,XX(2).GE.1.AND.NNQ(2).GE.1;
123          ALTER,BLINK1,1,1;
124          ACTIVITY,.05,,EHAE;
```

Figure C-6. Blinker Mechanism.

The above discussion covers the activity of one type of
asset at one base. Note that there are four bases each with
five different types of assets. The above sections of code
are repeated for each part at each base.

Depot Supply. Refer to Figures C-7 and C-8 for the
following discussion. Requisitions to depot supply from the
bases for the different types of assets arrive at depot
supply at line 360. Lines 361 through 365 sort the incoming
requisitions by type of asset. The first type of asset
requisition queues up FIFO at line 366 and wait for a
"blinker mechanism" to allow the requisitions to be
processed. After a requisition is allowed to be processed,
lines 367 through 370 reset the resource associated with the
"blinker mechanism."

148

```
360  DS    GOON,1;
361        ACTIVITY/76,,ATRIB(4).EQ.1;
362        ACTIVITY/77,,ATRIB(4).EQ.2,ZAFU;
363        ACTIVITY/78,,ATRIB(4).EQ.3,ZAFY;
364        ACTIVITY/79,,ATRIB(4).EQ.4,ZAGC;
365        ACTIVITY/80,,ATRIB(4).EQ.5,ZAGG;
366        AWAIT(12),BLINK6,,1;
367        ACTIVITY;
368        ALTER,BLINK6,-1,1;
369        ACTIVITY;
370        FREE,BLINK6,1;
371        ACTIVITY;
372        ASSIGN,XX(31)=XX(31)-1,1;
373        ACTIVITY,,ATRIB(2).EQ.1;
374        ACTIVITY,,ATRIB(2).EQ.2,ZAFO;
375        ACTIVITY,,ATRIB(2).EQ.3,ZAFP;
376        ACTIVITY,,ATRIB(2).EQ.4,ZAFQ;
377        GOON,1;
378        ACTIVITY;
379        ASSIGN,XX(21)=XX(21)+77.70,1;
380        ACTIVITY/81,ATRIB(8);
381        ASSIGN,XX(2)=XX(2)+1,1;
382        ACTIVITY;
383        TERMINATE;
384  ZAFO  GOON,1;
385        ACTIVITY;
386        ASSIGN,XX(21)=XX(21)+12.95,1;
387        ACTIVITY,ATRIB(8);
388        ASSIGN,XX(40)=XX(40)+1,1;
389        TERMINATE;
390  ZAFP  GOON,1;
391        ACTIVITY;
392        ASSIGN,XX(21)=XX(21)+77.70,1;
393        ACTIVITY,ATRIB(8);
394        ASSIGN,XX(50)=XX(50)+1,1;
395        TERMINATE;
396  ZAFQ  GOON,1;
397        ACTIVITY;
398        ASSIGN,XX(21)=XX(21)+18.13,1;
399        ACTIVITY,ATRIB(8);
400        ASSIGN,XX(60)=XX(60)+1,1;
401        TERMINATE;
```

Figure C-7. Depot Supply.
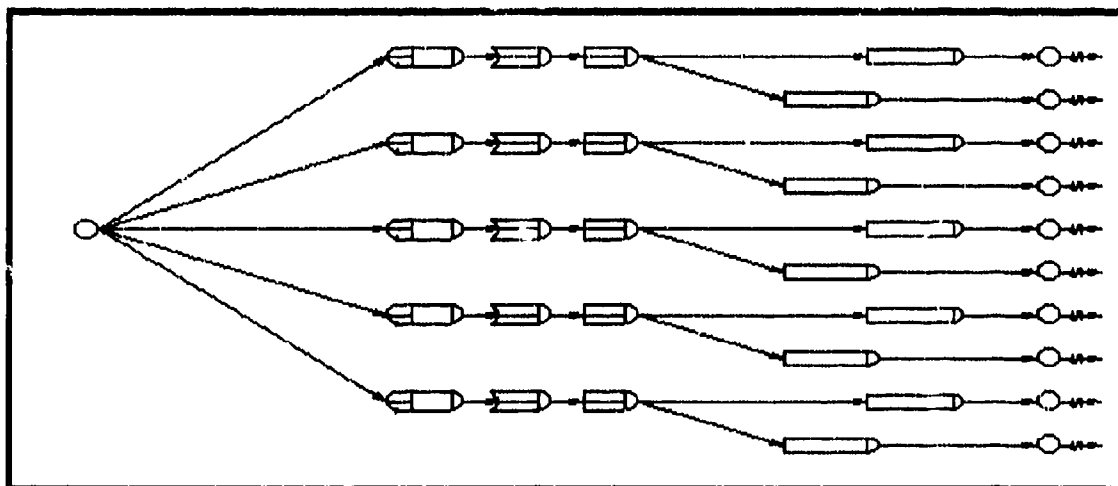
Figure C-8. Graphical Representation of Depot Supply.

149

Once the requisition has been released to be processed, the part is taken from the shelf at depot supply and the number of spares for that type of asset is decremented in line 372. Lines 373 through 376 sort the replenihment part according to which base requisitioned it. For example, if the part was ordered by Ellsworth the part jumps down from line 373 to line 377. Line 379 totals up thetransportation cost. The part is shipped to the base via line 380 and line 381 increments the number of serviceable spares at the base supply.

The above discussion followed one asset into depot supply where it was sorted according to type of asset then shipped to the base that ordered it. The section of code that performs this process is repeated for each type of asset requisition. And then for each type of asset requistion, the replenishment part is sorted according to its destination base.

Depot Repair. Refer to Figure C-9 and C-10 for the following discussion. Broken parts arrive at the depot repair function from the bases at line 589. Lines 590 through 594 sort the broken parts according to type of asset. The first type of assets queue up FIFO at line 595 while they wait for a "blinker mechanism" to allow them to be repaired. For treatments with a high asset level factor, the "blinker mechanism" allows all assets to be repaired as

soon as they arrive. For treatments with medium and low asset level factors, the "blinker mechanism" only allows parts to be repaired if the intermediate supply points are below their authorized stockage level.

Once the asset is allowed to be repaired, lines 596 through 599 reset the resource associated with the "blinker mechanism."

The assets are repaired in line 600. The parts can be condemned in line 601. The assets that were repaired are placed on the shelf at depot/ISP supply via line 602 and the number of serviceable spares at depot/ISP supply is incremented.

The above discussion followed one broken part as it came into the depot repair function, was sorted according to type of asset, repaired or condemned, and place on the shelf at depot/ISP supply. This section of code is repeated for each of the five different types of parts.

```
589   DR    GOON,1;
590         ACTIVITY/86,,ATRIB(4).EQ.1;
591         ACTIVITY/87,,ATRIB(4).EQ.2,ZAHB;
592         ACTIVITY/88,,ATRIB(4).EQ.3,ZAHD;
593         ACTIVITY/89,,ATRIB(4).EQ.4,ZAHF;
594         ACTIVITY/90,,ATRIB(4).EQ.5,ZAHH;
595         AWAIT(22),BLINK11,,1;
596         ACTIVITY;
597         ALTER,BLINK11,-1,1;
598         ACTIVITY;
599         FREE,BLINK11,1;
600         ACTIVITY/91,ATRIB(10),ATRIB(11);
601         ACTIVITY/92,,ATRIB(12),ZAGZ;
602         ASSIGN,XX(31)=XX(31)+1,1;
603         ACTIVITY;
604         TERMINATE;
605   ZAGZ  ASSIGN,XX(11)=XX(11)+1,1;
606         ACTIVITY;
607         TERMINATE;
```

Figure C-9. Depot Repair.
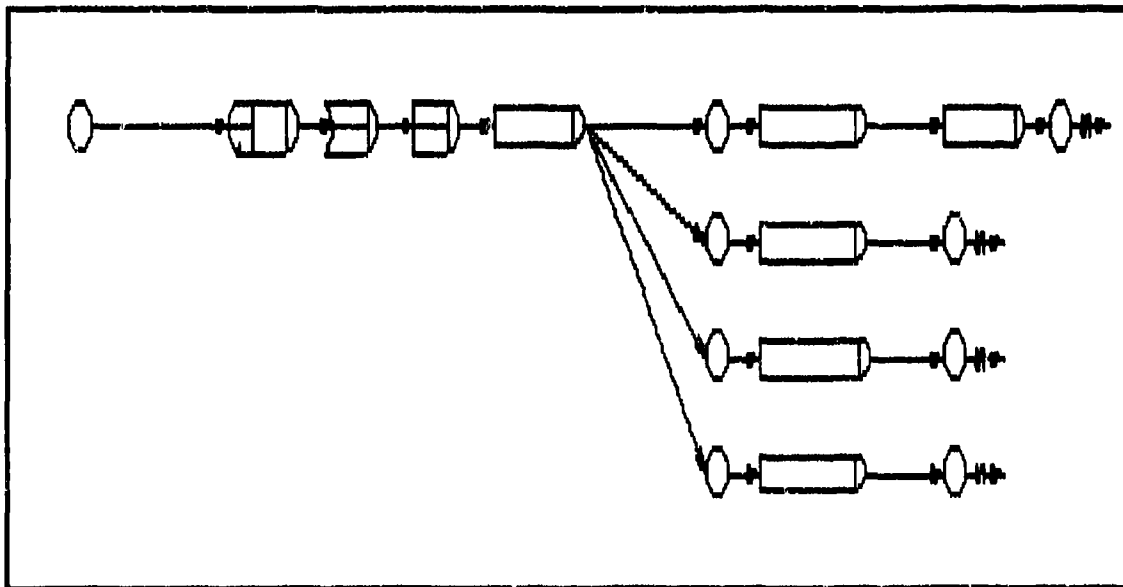
Figure C-10. Graphical Representation of Depot Repair.

Wilk–Shapiro / Rankit Plot of AA
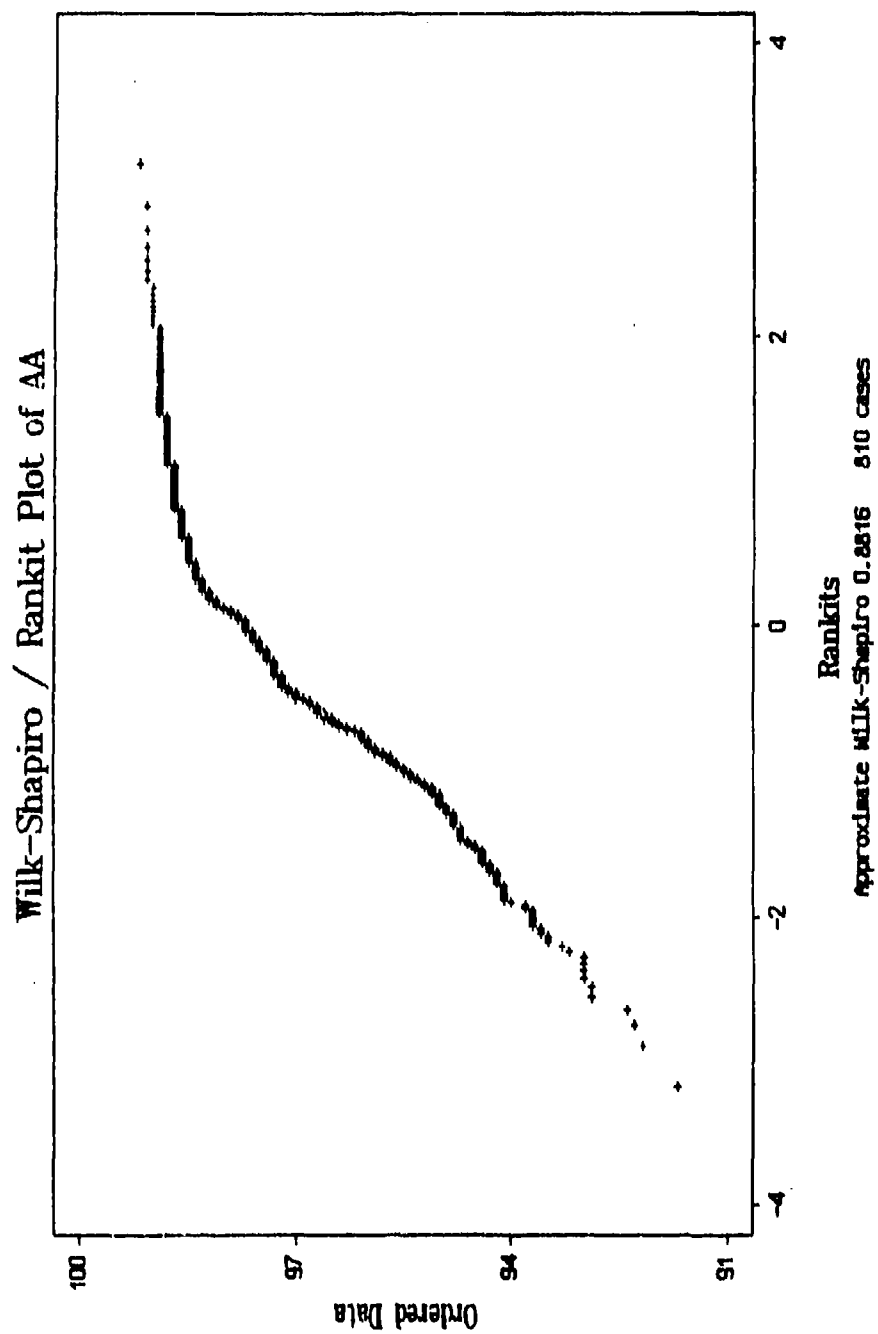
Wilk-Shapiro / Rankit Plot of TC

Ordered Data X 10E5
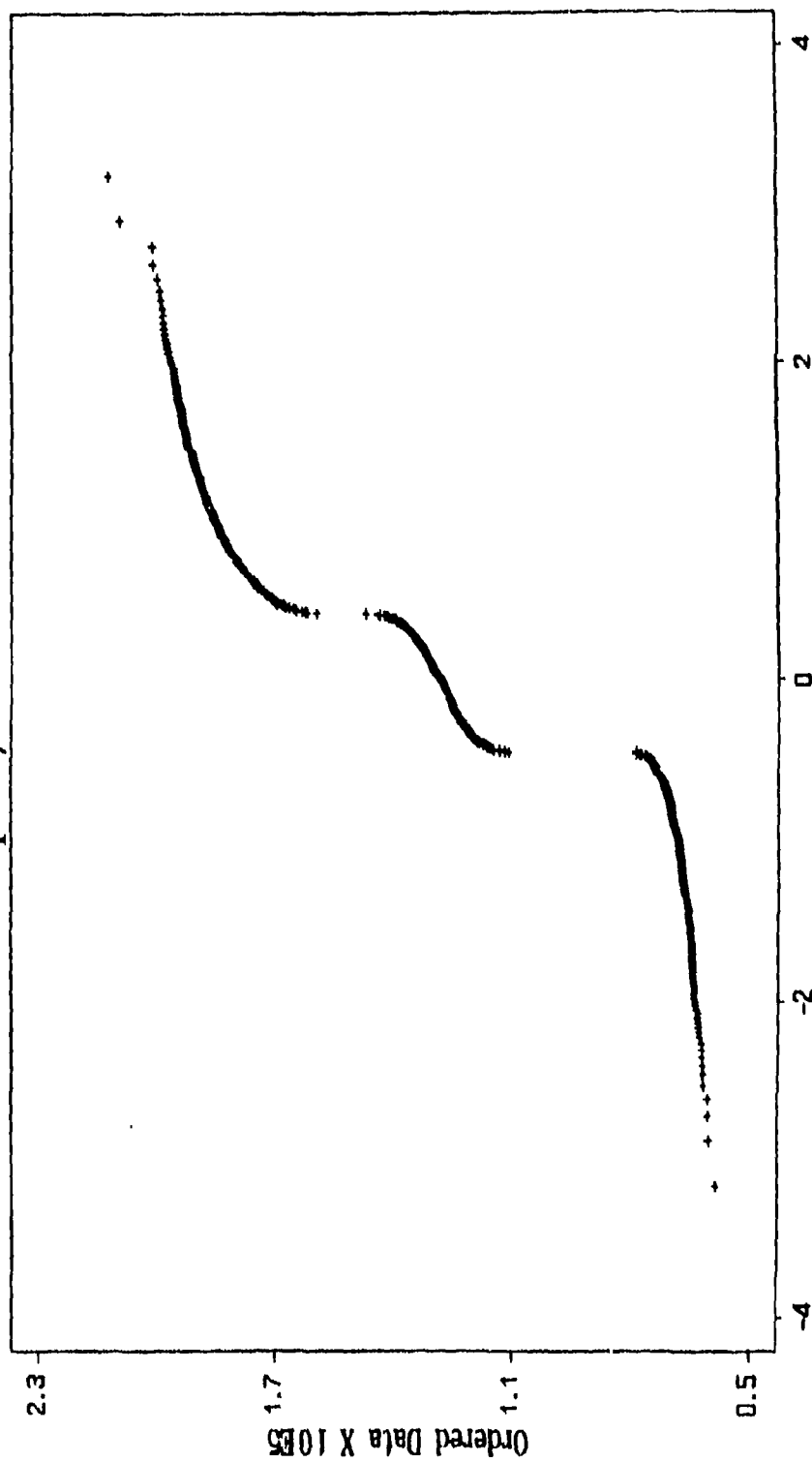
Rankits

Approximate Wilk-Shapiro 0.8606   810 cases

154

Appendix E: Output Data

TREAT	TRANSCOST	AA
H H H	62778.23	97.7
H H H	69953.91	97.6
H H H	67136.6	97.6
H H H	68376.42	97.7
H H H	68202.4	97.3
H H H	64547.53	97.6
H H H	65240.29	97.3
H H H	64313.29	97.3
H H H	75352.73	96.7
H H H	71760.43	95.1
H H H	62115.73	98.2
H H H	67414.9	98.2
H H H	65458.28	97.2
H H H	67496.85	96.7
H H H	73626.84	97.1
H H H	62067.85	97.5
H H H	69608.02	97.3
H H H	73533.76	96.3
H H H	77513.42	96.2
H H H	68831.41	97.3
H H H	73101.88	96
H H H	64704.99	97.1
H H H	67196.08	98.1
H H H	64791.39	97.6
H H H	71651.91	98.1
H H H	73528.03	97.4
H H H	69851	96.7
H H H	73573.49	96.3
H H H	71918.51	97.7
H H H	64911.57	97
H H M	127080.3	98.6
H H M	120627.1	98.6
H H M	127800.8	98.2
H H M	121329.4	98.1
H H M	124527.8	98.2
H H M	115180.5	98.3
H H M	125355.2	98.3
H H M	127357.6	98.2
H H M	125391.5	98.4
H H M	125238.5	98.3
H H M	123092.8	98.3

H	H	M	134435.9	97.7
H	H	M	123641.3	98.1
H	H	M	143595.2	98.1
H	H	M	135628.4	98
H	H	M	126817.6	98.4
H	H	M	119374.5	97.9
H	H	M	130446.3	98.3
H	H	M	138464.1	98.3
H	H	M	126128.4	98.3
H	H	M	129374.2	98.1
H	H	M	125996.6	98.7
H	H	M	127192.3	98.4
H	H	M	140021.6	98.4
H	H	M	129276.5	98.6
H	H	M	137017.7	98.6
H	H	M	121765.2	98.7
H	H	M	124349.2	98.2
H	H	M	140529.2	98.1
H	H	M	124589.4	98.2
H	H	L	183980.9	98.8
H	H	L	185994.2	98.8
H	H	L	178265	98.7
H	H	L	193735.1	98.9
H	H	L	184231	98.7
H	H	L	190227.7	99
H	H	L	184154.7	98.9
H	H	L	184545.4	99.1
H	H	L	188732.9	98.9
H	H	L	162589.8	98.9
H	H	L	187090.9	98.8
H	H	L	188900.6	99
H	H	L	182874.5	99
H	H	L	192772	99.1
H	H	L	176244.8	98.7
H	H	L	175528.8	98.5
H	H	L	184224.6	98.7
H	H	L	189776	98.7
H	H	L	196062.4	98.9
H	H	L	199344.7	98.8
H	H	L	163243.4	98.9
H	H	L	179046.6	98.8
H	H	L	192769.6	98.9
H	H	L	189761.7	99
H	H	L	190454.8	98.8
H	H	L	187347.6	99
H	H	L	201158.1	98.9
H	H	L	198044.5	98.9
H	H	L	188557.9	98.6
H	H	L	191430.3	98.9

H	M	H	65063.04	97.7
H	M	H	69898.48	97.3
H	M	H	72799.95	96.7
H	M	H	70106.52	97.4
H	M	H	65447.66	97.5
H	M	H	62587.03	97.9
H	M	H	69997.25	97.3
H	M	H	69779.41	97.4
H	M	H	74335.62	96.3
H	M	H	60746.26	97.5
H	M	H	67197.7	97.1
H	M	H	69337.99	96.7
H	M	H	61918.76	97.7
H	M	H	68056.09	97.4
H	M	H	67538.79	97.3
H	M	H	64399.84	97.3
H	M	H	64294.93	97.7
H	M	H	73702.77	95.3
H	M	H	70037.03	97.7
H	M	H	71849.2	97.3
H	M	H	63714.07	97.3
H	M	H	61604.42	97.3
H	M	H	70838.7	97.5
H	M	H	66070.73	96.4
H	M	H	69926.95	96
H	M	H	70787.71	97.8
H	M	H	69355.28	97.5
H	M	H	67844.83	96.1
H	M	H	76556.7	95.4
H	M	H	66575.63	96.1
H	M	M	130421.5	98.5
H	M	M	127926.7	98.5
H	M	M	128090.9	98.3
H	M	M	124803	98.2
H	M	M	135062.1	98.5
H	M	M	127085.1	98.6
H	M	M	123766.6	98
H	M	M	127421.7	98.4
H	M	M	134394.7	98.2
H	M	M	119331.2	98.6
H	M	M	131796.6	97.9
H	M	M	131320.4	98.2
H	M	M	121099.6	98.1
H	M	M	127045.3	98.7
H	M	M	122526.8	98.3
H	M	M	124645.7	98.3
H	M	M	122299.7	98.9
H	M	M	134516.8	97.8
H	M	M	131827.7	98.2

H	M	M	135890.7	97.9
H	M	M	135621	97.7
H	M	M	116823.1	98.3
H	M	M	131115.1	98.1
H	M	M	125540.3	97.9
H	M	M	135868.6	98
H	M	M	132496.9	98.9
H	M	M	133711.5	98.4
H	M	M	134207.7	98.5
H	M	M	124777	98.5
H	M	M	120931.8	98.7
H	M	L	192863.4	98.9
H	M	L	161942.8	98.6
H	M	L	176360.7	98.8
H	M	L	188728.1	98.7
H	M	L	179823.5	98.9
H	M	L	180959.7	98.9
H	M	L	167549.1	98.7
H	M	L	194902.6	98.7
H	M	L	179859.6	98.7
H	M	L	179382.9	98.5
H	M	L	173654.4	98.9
H	M	L	189054.1	98.5
H	M	L	175296.3	98.6
H	M	L	187300.2	98.9
H	M	L	174650.4	98.9
H	M	L	180517	98.7
H	M	L	186551.7	98.5
H	M	L	183013.9	98.7
H	M	L	209352.3	98.8
H	M	L	186322	98.7
H	M	L	185027.6	98.9
H	M	L	170641.2	99.1
H	M	L	180937.3	98.7
H	M	L	196404	98.8
H	M	L	191112.5	98.8
H	M	L	177152.5	99.1
H	M	L	185540	98.9
H	M	L	185690.3	98.4
H	M	L	194125.7	98.6
H	M	L	170992.4	98.9
H	L	H	66504.13	96.4
H	L	H	70704.77	96.8
H	L	H	72138.23	95.6
H	L	H	65483.9	96.6
H	L	H	65808.3	97.2
H	L	H	64052.3	96.7
H	L	H	67469.47	95.7
H	L	H	68841.42	95.2

H	L	H	74753.17	94.8
H	L	H	63157.96	97.1
H	L	H	65066.63	96
H	L	H	64381.52	96.6
H	L	H	70875.9	96
H	L	H	69451.76	96.5
H	L	H	78772.41	94.5
H	L	H	67009.57	95.5
H	L	H	69442.92	95.5
H	L	H	75964.83	93
H	L	H	77909.4	96
H	L	H	62974.22	95.9
H	L	H	68085.5	96.7
H	L	H	70457.16	95
H	L	H	71376.13	96.1
H	L	H	68040.27	94.3
H	L	H	66679.69	95.8
H	L	H	66268.01	96.5
H	L	H	73358.27	95
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L L H      69451.76    96.5
L L H      78772.41    94.5
L L H      67009.57    95.5
L L H      69442.92    95.5
L L H      75964.83    93
L L H      77909.4     96
L L H      62974.22    95.9
L L H      68085.5     96.7
L L H      70457.16    95
L L H      71376.13    96.1
L L H      68040.27    94.3
L L H      66679.69    95.8
L L H      66268.01    96.5
L L H      73358.27    95
L L H      74053.64    96.2
L L H      65723.09    94.7
L L H      74480.71    95
L L M     130481.5     97.7
L L M     139507.9     97
L L M     130200.7     97.3
L L M     135301.9     97.3
L L M     118387.3     97.5
L L M     126661.1     97.5
L L M     118537.1     97.6
L L M     133273.4     97.7
L L M     111905       97.2
L L M     129251.3     97.3
L L M     126326.6     97.4
L L M     125890.4     97.2
L L M     125128.6     97.4
L L M     126573.5     97.1
L L M     124178.4     97.6
L L M     131669.7     97.8
L L M     125387.2     97.6
I L M     129977.1     97.4
L L M     144095       97.3
L L M     132783.4     97.4
L L M     130976.4     97.2
L L M     128727.6     97.4
L L M     137354.4     97.6
L L M     123046.1     97.2
L L M     132185.2     97.7
L L M     129841.4     97.4
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L  L  M      123096.7   97.5
L  L  M      131229.7   97.1
L  L  M      135452.8   97.2
L  L  M      137439.9   97.6
L  L  L      183999.5   98.8
L  L  L      170025.1   98.8
L  L  L      175279.8   98.5
L  L  L      175005.3   98.7
L  L  L      168403.4   98.8
L  L  L      181023.4   98.3
L  L  L      170246.4   98.6
L  L  L      174662     98.8
L  L  L      165144.8   98.4
L  L  L      171686.1   98.4
L  L  L      164814.5   98.6
I. I. L      181789.4   98.3
L  L  L      182627.9   98.3
L  L  L      194695.9   98.7
L  L  L      176572.3   98.5
L  L  L      172963     98.7
L  L  L      190271.2   98.7
L  L  L      195332.1   98.4
L  L  L      195668.1   98.4
L  L  L      172815.6   98.7
L  L  L      185976.4   98.3
L  L  L      187263.2   98.4
L  L  L      192152.4   98.5
L  L  L      189200.7   98.7
L  L  L      193440.6   98.6
L  L  L      178008.4   98.7
L  L  L      172938.8   98.6
L  L  L      177869.6   98.5
L  L  L      190430.9   98.5
L  L  L      188857.2   98.6
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Appendix F: STATISTIX Output Files

Kruskal-Wallis One-Way AOV for Aircraft Availability.

STATISTIX 4.0
08/15/94, 20:23

KRUSKAL-WALLIS ONE-WAY NONPARAMETRIC AOV FOR AA BY TRT

TRT	MEAN RANK	SAMPLE SIZE
HHH	319.4	30
HHL	741.6	30
HHM	512.6	30
HLH	160.6	30
HLL	720.4	30
HLM	558.4	30
HMH	304.2	30
HML	698.0	30
HMM	529.6	30
LHH	55.9	30
LHL	674.9	30
LHM	257.0	30
LLH	160.6	30
LLL	605.8	30
LLM	340.0	30
LMH	82.5	30
LML	602.1	30
LMM	348.3	30
MHH	93.1	30
MHL	690.3	30
MHM	306.1	30
MLH	93.1	30
MLL	605.8	30
MLM	373.9	30
MMH	135.3	30
MML	615.5	30
MMM	363.4	30
TOTAL	405.5	810

KRUSKAL-WALLIS STATISTIC   735.1333
P-VALUE, USING CHI-SQUARED APPROXIMATION   0.0000

PARAMETRIC AOV APPLIED TO RANKS

SOURCE	DF	SS	MS	F	P
BETWEEN	26	4.018E+07	1.545E+06	299.71	0.0000
WITHIN	783	4.037E+06	5156.11		
TOTAL	809	4.422E+07			

TOTAL NUMBER OF VALUES THAT WERE TIED 802
MAX. DIFF. ALLOWED BETWEEN TIES   0.00001

CASES INCLUDED 810   MISSING CASES 0

Rank Sum Tests for Adjacent Treatments of Aircraft

Availability.

STATISTIX 4.0
T, 08/15/94, 22:26

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR AA BY TRT

TRT	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
HHH	1360.5	30	895.50	45.4
LHH	469.50	30	4.5000	15.7
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   6.579
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.0000

TOTAL NUMBER OF VALUES THAT WERE TIED   43
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

STATISTIX 4.0
T, 08/15/94, 22:28

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR AA BY TRT

TRT	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
HHH	1317.5	30	852.50	43.9
MMH	512.50	30	47.500	17.1
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   5.943
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.0000

TOTAL NUMBER OF VALUES THAT WERE TIED   48
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

STATISTIX 4.0
T, 08/15/94, 22:14

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR AA BY TRT

TRT	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
HHL	1350.0	30	885.00	45.0
HHM	480.00	30	15.000	16.0
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   6.424
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.0000

TOTAL NUMBER OF VALUES THAT WERE TIED   56
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

STATISTIX 4.0
T, 08/15/94, 22:10

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR AA BY TRT

TRT	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
HHL	1365.0	30	900.00	45.5
LHM	465.00	30	0.0000	15.5
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   6.646
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.0000

TOTAL NUMBER OF VALUES THAT WERE TIED   48
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

STATISTIX 4.0
T, 08/15/94, 22:16

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR AA BY TRT

TRT	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
HHM	1350.5	30	885.50	45.0
LMM	479.50	30	14.500	16.0
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   6.431
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.0000

TOTAL NUMBER OF VALUES THAT WERE TIED   54
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

STATISTIX 4.0
T, 08/15/94, 22:23

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR AA BY TRT

TRT	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
HLH	1183.5	30	718.50	39.5
LMH	646.50	30	181.50	21.6
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   3.962
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.0001

TOTAL NUMBER OF VALUES THAT WERE TIED   45
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

STATISTIX 4.0
T, 08/15/94, 21:33

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR AA BY TRT

TRT	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
HLL	1202.5	30	737.50	40.1
MML	627.50	30	162.50	20.9
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   4.243
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.0000

TOTAL NUMBER OF VALUES THAT WERE TIED   59
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

STATISTIX 4.0
T, 08/15/94, 22:05

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR AA BY TRT

TRT	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
HLM	1044.0	30	579.00	34.8
HMM	786.00	30	321.00	26.2
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   1.900
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.0575

TOTAL NUMBER OF VALUES THAT WERE TIED   58
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0 00001

CASES INCLUDED 60   MISSING CASES 0

STATISTIX 4.0
T, 08/15/94, 22:07

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR AA BY TRT

TRT	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
HLM	1365.0	30	900.00	45.5
LHM	465.00	30	0.0000	15.5
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   6.646
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.0000

TOTAL NUMBER OF VALUES THAT WERE TIED   49
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

STATISTIX 4.0
T, 08/15/94, 22:46

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR AA BY TRT

TRT	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
HMH	1344.0	30	879.00	44.8
MHH	486.00	30	21.000	16.2
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   6.335
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.0000

TOTAL NUMBER OF VALUES THAT WERE TIED   44
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

STATISTIX 4.0
T, 08/15/94, 22:04

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR AA BY TRT

TRT	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
HMM	1355.0	30	890.00	45.2
MHM	475.00	30	10.000	15.8
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   6.498
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.0000

TOTAL NUMBER OF VALUES THAT WERE TIED   55
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

STATISTIX 4.0
T, 08/15/94, 22:25

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR AA BY TRT

TRT	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
LHH	793.00	30	328.00	26.4
LMH	1037.0	30	572.00	34.6
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   1.796
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.0724

TOTAL NUMBER OF VALUES THAT WERE TIED   44
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

STATISTIX 4.0
T, 08/15/94, 21:26

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR AA BY TRT

TRT	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
LHL	851.50	30	386.50	28.4
MHL	978.50	30	513.50	32.6
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   0.931
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.3516

TOTAL NUMBER OF VALUES THAT WERE TIED   59
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

STATISTIX 4.0
T, 08/15/94, 22:20

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR AA BY TRT

TRT	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
HLH	915.00	30	450.00	30.5
LLH	915.00	30	450.00	30.5
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   -0.007
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.9941

TOTAL NUMBER OF VALUES THAT WERE TIED   60
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

STATISTIX 4.0
T, 08/15/94, 22:18

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR AA BY TRT

TRT	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
LLH	477.50	30	12.500	15.9
LMM	1352.5	30	887.50	45.1
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   6.461
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.0000

TOTAL NUMBER OF VALUES THAT WERE TIED   43
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

STATISTIX 4.0
T, 08/15/94, 21:45

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR AA BY TRT

| | | SAMPLE | | |
TRT	RANK SUM	SIZE	U STAT	MEAN RANK
LLL	915.00	30	450.00	30.5
MLL	915.00	30	450.00	30.5
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   -0.007
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.9941

TOTAL NUMBER OF VALUES THAT WERE TIED   60
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

STATISTIX 4.0
T, 08/15/94, 21:57

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR AA BY TRT

| | | SAMPLE | | |
TRT	RANK SUM	SIZE	U STAT	MEAN RANK
LLM	764.00	30	299.00	25.5
MLM	1066.0	30	601.00	35.5
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   2.225
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.0261

TOTAL NUMBER OF VALUES THAT WERE TIED   58
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

STATISTIX 4.0
T, 08/15/94, 21:36

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR AA BY TRT

TRT	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
HML	1160.0	30	695.00	38.7
LML	670.00	30	205.00	22.3
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   3.615
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.0003

TOTAL NUMBER OF VALUES THAT WERE TIED   58
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

STATISTIX 4.0
T, 08/15/94, 22:44

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR AA BY TRT

TRT	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
MHH	915.00	30	450.00	30.5
MLH	915.00	30	450.00	30.5
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   -0.007
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.9941

TOTAL NUMBER OF VALUES THAT WERE TIED   60
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

STATISTIX 4.0
T, 08/15/94, 21:28

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR AA BY TRT

TRT	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
HLL	1043.5	30	578.50	34.8
MHL	786.50	30	321.50	26.2
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   1.892
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.0584

TOTAL NUMBER OF VALUES THAT WERE TIED   58
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

STATISTIX 4.0
T, 08/15/94, 22:02

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR AA BY TRT

TRT	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
MHM	726.00	30	261.00	24.2
MMM	1104.0	30	639.00	36.8
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   2.787
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.0053

TOTAL NUMBER OF VALUES THAT WERE TIED   55
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001
CASES INCLUDED 60   MISSING CASES 0

STATISTIX 4.0
T, 08/15/94, 22:30

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR AA BY TRT

TRT	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
MLH	724.50	30	259.50	24.2
MMH	1105.5	30	640.50	36.9
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   2.809
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.0050

TOTAL NUMBER OF VALUES THAT WERE TIED   54
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

STATISTIX 4.0
T, 08/15/94, 21:52

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR AA BY TRT

TRT	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
LLM	465.00	30	0.0000	15.5
MLL	1365.0	30	900.00	45.5
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   6.646
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.0000

TOTAL NUMBER OF VALUES THAT WERE TIED   58
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

STATISTIX 4.0
T, 08/15/94, 22:00

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR AA BY TRT

		SAMPLE		
TRT	RANK SUM	SIZE	U STAT	MEAN RANK
---	---	---	---	---
MLM	956.50	30	491.50	31.9
MMM	873.50	30	408.50	29.1
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   0.606
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.5444

TOTAL NUMBER OF VALUES THAT WERE TIED   55
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

STATISTIX 4.0
T, 08/15/94, 21:35

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR AA BY TRT

		SAMPLE		
TRT	RANK SUM	SIZE	U STAT	MEAN RANK
---	---	---	---	---
LML	870.50	30	405.50	29.0
MML	959.50	30	494.50	32.0
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   0.651
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.5154

TOTAL NUMBER OF VALUES THAT WERE TIED   58
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

Kruskal-Wallis One-Way AOV for Transportation Cost.

```
STATISTIX 4.0
T, 08/16/94, 21:06
KRUSKAL-WALLIS ONE-WAY NONPARAMETRIC AOV FOR TC BY TRT
```

TRT	MEAN RANK	SAMPLE SIZE
HHH	134.4	30
HHL	703.3	30
HHM	399.5	30
HLH	142.9	30
HLL	680.0	30
HLM	404.8	30
HMH	126.6	30
HML	667.9	30
HMM	411.1	30
LHH	139.4	30
LHL	690.2	30
LHM	400.8	30
LLH	142.9	30
LLL	652.8	30
LLM	419.1	30
LMH	142.5	30
LML	668.4	30
LMM	370.9	30
MHH	128.4	30
MHL	686.8	30
MHM	411.6	30
MLH	128.4	30
MLL	652.8	30
MLM	417.6	30
MMH	134.2	30
MML	677.4	30
MMM	414.2	30
TOTAL	405.5	810

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KRUSKAL-WALLIS STATISTIC                        721.5043
P-VALUE, USING CHI-SQUARED APPROXIMATION          0.0000
PARAMETRIC AOV APPLIED TO RANKS
```

SOURCE	DF	SS	MS	F	P
BETWEEN	26	3.950E+07	1.519E+06	248.34	0.0000
WITHIN	783	4.790E+06	6117.14		
TOTAL	809	4.429E+07			

```
TOTAL NUMBER OF VALUES THAT WERE TIED   186
MAX. DIFF. ALLOWED BETWEEN TIES       0.00001
```

Rank Sum Tests for Adjacent Treatments of Transportation Cost.

STATISTIX 4.0
T, 08/16/94, 23:24

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

		SAMPLE		
TRT	RANK SUM	SIZE	U STAT	MEAN RANK
HHH	911.00	30	446.00	30.4
LHH	919.00	30	454.00	30.6
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   0.052
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.9587

TOTAL NUMBER OF VALUES THAT WERE TIED   0
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

STATISTIX 4.0
T, 08/16/94, 23:40

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

		SAMPLE		
TRT	RANK SUM	SIZE	U STAT	MEAN RANK
HHM	914.00	30	449.00	30.5
LHM	916.00	30	451.00	30.5
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   0.007
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.9941

TOTAL NUMBER OF VALUES THAT WERE TIED   0
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

STATISTIX 4.0
T, 08/16/94, 23:33

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

TRT	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
HLH	915.00	30	450.00	30.5
LLH	915.00	30	450.00	30.5
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   -0.00?
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.9??1

TOTAL NUMBER OF VALUES THAT WERE TIED   60
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

STATISTIX 4.0
T, 08/17/94, 0:05

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

TRT	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
HLL	898.00	30	433.00	29.9
MHL	932.00	30	467.00	31.1
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   0.244
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.8073

TOTAL NUMBER OF VALUES THAT WERE TIED   0
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001
CASES INCLUDED 60   MISSING CASES 0

STATISTIX 4.0
T, 08/17/94, 0:05

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

TRT	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
HLL	898.00	30	433.00	29.9
MHL	932.00	30	467.00	31.1
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   0.244
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.8073

TOTAL NUMBER OF VALUES THAT WERE TIED   0
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

STATISTIX 4.0
T, 08/16/94, 23:43

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

TRT	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
HLM	898.00	30	433.00	29.9
HMM	932.00	30	467.00	31.1
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   0.244
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.8073

TOTAL NUMBER OF VALUES THAT WERE TIED   0
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

STATISTIX 4.0
T, 08/16/94, 23:12

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

TRT	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
HMH	909.00	30	444.00	30.3
MHH	921.00	30	456.00	30.7
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   0.081
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.9352

TOTAL NUMBER OF VALUES THAT WERE TIED   0
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

STATISTIX 4.0
T, 08/16/94, 23:57

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

TRT	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
HML	922.00	30	457.00	30.7
LML	908.00	30	443.00	30.3
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   0.096
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.9234

TOTAL NUMBER OF VALUES THAT WERE TIED   0
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

STATISTIX 4.0
T, 08/16/94, 23:45

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

TRT	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
HMM	916.00	30	451.00	30.5
MHM	914.00	30	449.00	30.5
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   0.007
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.9941

TOTAL NUMBER OF VALUES THAT WERE TIED   0
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

STATISTIX 4.0
T, 08/16/94, 23:28

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

TRT	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
LHH	904.00	30	439.00	30.1
LMH	926.00	30	461.00	30.9
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   0.155
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.8766

TOTAL NUMBER OF VALUES THAT WERE TIED   0
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

STATISTIX 4.0
T, 08/17/94, 0:09

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

TRT	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
HHL	970.00	30	505.00	32.3
LHL	860.00	30	395.00	28.7
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   0.806
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.4204

TOTAL NUMBER OF VALUES THAT WERE TIED   0
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

STATISTIX 4.0
T, 08/16/94, 23:42

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

TRT	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
HLM	923.00	30	458.00	30.8
LHM	907.00	30	442.00	30.2
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   0.111
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.9117

TOTAL NUMBER OF VALUES THAT WERE TIED   0
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

STATISTIX 4.0
T, 08/16/94, 23:37

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

TRT	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
LLH	465.00	30	0.0000	15.5
LMM	1365.0	30	900.00	45.5
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   6.646
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.0000

TOTAL NUMBER OF VALUES THAT WERE TIED   0
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

STATISTIX 4.0
T, 08/16/94, 23:53

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

TRT	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
LLL	915.00	30	450.00	30.5
MLL	915.00	30	450.00	30.5
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   -0.007
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.9941

TOTAL NUMBER OF VALUES THAT WERE TIED   60
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

STATIST . 4.0
T, 08/16/94, 23:52

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

TRT	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
LLL	1365.0	30	900.00	45.5
LLM	465.00	30	0.0000	15.5
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   6.646
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.0000

TOTAL NUMBER OF VALUES THAT WERE TIED   0
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

STATISTIX 4.0
T, 08/16/94, 23:31

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

TRT	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
HLH	921.00	30	456.00	30.7
LMH	909.00	30	444.00	30.3
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   0.081
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.9352

TOTAL NUMBER OF VALUES THAT WERE TIED   0
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

STATISTIX 4.0
T, 08/16/94, 23:58

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

| | | SAMPLE | | |
TRT	RANK SUM	SIZE	U STAT	MEAN RANK
LML	876.50	30	411.50	29.2
MML	953.50	30	488.50	31.8
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   0.562
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.5742

TOTAL NUMBER OF VALUES THAT WERE TIED   2
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

STATISTIX 4.0
T, 08/16/94, 23:39

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

| | | SAMPLE | | |
TRT	RANK SUM	SIZE	U STAT	MEAN RANK
HHM	1022.0	30	557.00	34.1
LMM	808.00	30	343.00	26.9
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   1.575
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.1154

TOTAL NUMBER OF VALUES THAT WERE TIED   0
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

STATISTIX 4.0
T, 08/16/94, 23:18

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

TRT	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
MHH	915.00	30	450.00	30.5
MLH	915.00	30	450.00	30.5
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   -0.007
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.9941

TOTAL NUMBER OF VALUES THAT WERE TIED   60
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

STATISTIX 4.0
T, 08/17/94, 0:07

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

TRT	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
LHL	934.00	30	469.00	31.1
MHL	896.00	30	431.00	29.9
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   0.274
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.7845

TOTAL NUMBER OF VALUES THAT WERE TIED   0
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

STATISTIX 4.0
T, 08/16/94, 23:47

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

TRT	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
MHM	905.00	30	440.00	30.2
MMM	925.00	30	460.00	30.8
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   0.140
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.8883

TOTAL NUMBER OF VALUES THAT WERE TIED   0
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

STATISTIX 4.0
T, 08/16/94, 23:20

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

TRT	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
MLH	886.00	30	421.00	29.5
MMH	944.00	30	479.00	31.5
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   0.421
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.6735

TOTAL NUMBER OF VALUES THAT WERE TIED   0
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

STATISTIX 4.0
T, 08/16/94, 23:55

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

TRT	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
HML	967.00	30	502.00	32.2
MLL	863.00	30	398.00	28.8
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   0.761
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.4464

TOTAL NUMBER OF VALUES THAT WERE TIED   0
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

STATISTIX 4.0
T, 08/16/94, 23:50

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

TRT	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
LLM	914.00	30	449.00	30.5
MLM	916.00	30	451.00	30.5
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   0.007
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.9941

TOTAL NUMBER OF VALUES THAT WERE TIED   4
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

STATISTIX 4.0
T, 08/16/94, 23:22

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

TRT	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
HHH	910.00	30	445.00	30.3
MMH	920.00	30	455.00	30.7
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   0.067
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.9470

TOTAL NUMBER OF VALUES THAT WERE TIED   0
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

STATISTIX 4.0
T, 08/17/94, 0:00

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

TRT	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
HLL	930.00	30	465.00	31.0
MML	900.00	30	435.00	30.0
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   0.214
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.8303

TOTAL NUMBER OF VALUES THAT WERE TIED   0
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

STATISTIX 4.0
T, 08/16/94, 23:49

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

TRT	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
MLM	925.00	30	460.00	30.8
MMM	905.00	30	440.00	30.2
TOTAL	1830.0	60		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION   0.140
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION   0.8883

TOTAL NUMBER OF VALUES THAT WERE TIED   0
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

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Vita

Captain Tracey L. Hill was born on 17 May 1967 in Athens, Pennsylvania. She graduated from Derry Area High School in Derry, Pennsylvania in 1985 and went on to attend the University of Pittsburgh. She graduated from the University of Pittsburgh with a Bachelor of Science in Business Administration in August of 1989. After receiving a reserve commission in the USAF, she was assigned to the 1st Tactical Fighter Wing, Langley AFB, VA where she served as the OIC, War Readiness Spares Kits Section. She attended the Supply Officer's Training Course at Lowry AFB in Denver, Colorado. In September of 1991, she was reassigned to the 8th Tactical Fighter Wing, Kunsan AB, Korea, where she served as the Flight Commander, Material Storage and Distribution, and the Flight Commander, Materiel Management. She entered the Graduate School of Logistics and Acquisition Management, Air Force Institute of Technology, in May 1993, and received a follow-on assignment to the Air Force Materiel Command Headquarters, LGI, Wright-Patterson Air Force Base, OH.

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Vita

Captain William N. Walker was born on 17 November 1966 in Taegu, South Korea. He graduated from Kubasaki High School in Okinawa, Japan in 1984 and went on to attend the University of Alabama. He graduated from the University of Alabama with a Bachelor of Science in Electrical Engineering and as Distinguished Graduate from AFROTC DET. 010 in May 1989. After receiving a reserve commission in the USAF, he attended the Aircraft Maintenance Officers Course at Chanute AFB, Illinois, graduating with Honors. In November 1989, he was assigned to the 405th Tactical Training Wing, Luke AFB, AZ where he served as OIC, Maintenance Plan Branch; OIC, Accessory Branch; and, finally, AOIC and OIC, 555 Fighter Squadron Maintenance. He entered the Graduate School of Logistics and Acquisition Management, Air Force Institute of Technology, in May 1993, and received a follow-on assignment to the Air Force Logistics Management Agency, Maintenance Directorate, Gunter Air Force Base, GA.

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13. ABSTRACT (Maximum 200 words)

This research investigates the effect of Lean Logistics proposals on the current Air Force reparables pipeline. Lean Logistics proposes reducing reparable asset levels at operating bases, reducing transportation time between bases and depots, and reducing depot repair times. Computer simulation is used as a tool to perform a 3X3X3 full factorial experiment to determine the effects of the Lean Logistics proposals on fully mission capable aircraft and transportation cost. Results indicate that Lean Logistics outperforms the current reparables pipeline in term of fully mission capable aircraft. A cost benefit analysis is performed to determine the trade offs between transportation costs and asset outlays.

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